SCIENCE AND TECHNICAL EDUCATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

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SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

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SCIENCE AND TECHNICAL EDUCATION

THURSDAY, JUNE 7, 1990

U.S. House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Science, Research and Technology,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:18 a.m., in room 2318, Rayburn House Office Building, Hon. Tim Valentine (chairman of the subcommittee) presiding.

Mr. Valentine. Good morning, ladies and gentlemen. We will get started. We had a vote which is our excuse today for beginning a little bit late.

Today and next Thursday, the subcommittee will receive testimony on proposed legislation to create several new science and technology education programs at the National Science Foundation. The new programs are designed to expand scientific literacy in the country, to improve technical training and technical training in advanced technology occupations, and increase the numbers of students pursuing careers in science and engineering.

The draft subcommittee bill is a vehicle for consideration of legislative initiatives which have been put forward by several Members. The section of the draft dealing with instructional technologies is based on H.R. 3122, introduced by Mr. Price, and H.R. 4331, introduced by Mr. Buechner. The provisions on informal science education are taken from H.R. 3154, introduced by Mr. Brown.

Programs directed toward community college instruction are based on H.R. 1720, introduced by Mr. Walgren, and S. 2114, introduced by Senator Kennedy. Finally, the award program for undergraduate teaching originates with H.R. 2270, also introduced by Mr. Brown.

Our intention in these hearings is to obtain a critical evaluation of the provisions of the draft bill. In particular, we will explore whether the proposed programs are tailored to address the most important issues and whether the programs are likely to achieve their intended objectives. Since previous subcommittee hearings which were held last year reviewed some of the programs now incorporated in the draft bill, the principal focus of these hearings will be on the other provisions, especially those involving undergraduate instruction and informal science education.

We will begin this morning by obtaining the Administration's position on the proposed legislation by a statement from the Director of the National Science Foundation, Mr. Bloch. We will then have two panels of witnesses who will discuss the provisions of the bill which attempt to increase the importance of undergraduate teaching in the reward system for university faculty.

We welcome the distinguished witnesses here today and others who have come to be with us. I will recognize our colleague, Mr. Brown, at this time.

Mr. BROWN. Do you want me to take a few minutes until the Republicans get here, Mr. Chairman? Is that the idea?

Mr. VALENTINE. You take a few minutes for whatever reason you want to. We don't need to wait for the Republicans. Excuse me, no offense intended; we have an understanding. [Laughter.]

Mr. BROWN. Thank you very much, Mr. Chairman.

Our national system of undergraduate science education is in trouble. Colleges and universities are unable to fulfill their mission of creating tomorrow's generation of scientists and engineers.

Our institutions of higher learning are failing to draw enough women and minorities into the technical disciplines. They are not ensuring that humanities majors, our future leaders in business, law, education, and politics, are sufficiently literate in science to function effectively in a technological world. They are not training an adequate number of teachers with the competency to teach science and math at the secondary and elementary school level and, more particularly, to make science and math attractive and interesting to the students at these levels.

These problems have complex causes, some of which lie beyond the immediate responsibility of our colleges and universities, but there is widespread agreement that the quality of undergraduate science teaching has seriously declined over the past several decades. After World War II, the Federal Government created the world's foremost basic scientific research establishment by mobilizing the great intellectual resources of our universities.

When Congress created the National Science Foundation, no one could have anticipated that this might be the first step in a process that could lead to the crippling of our undergraduate science education effort. As research became an increasingly important part of every academic scientist's responsibilities, the importance of teaching was proportionately diminished.

Now we find ourselves in an absurd position. In many university science departments, the criteria for hiring, firing, promoting, and granting tenure to faculty depend exclusively on research performance. Teaching is viewed as no more than a distraction from the higher priority of conducting research.

That is the bad news. The good news is that this course of events shows us that Congress can help provide the incentives that mold academic priorities. For example, I believe that the competitive grant system, which has fueled our academic research effort, may be applied successfully, even if on a much smaller scale, to science education as well, in order to increase the prestige and rewards associated with undergraduate science teaching.

An example of this type of program is included in the draft bill that we are considering today. We need to get away from the "publish or perish" mentality in our universities and replace it with an education or expire philosophy.

During this hearing, I hope that our distinguished witnesses can help us answer a fundamental question: how can we change the culture of academic science so that teaching is viewed by every faculty member as a fundamental, honorable, indeed, indispensable responsibility. In the words of Stanford President Donald Kennedy, "It is time for us to reaffirm that education—that is teaching in all of its forms—is the primary task and that our society will judge us in the long run on how well we do it."

Let me just make an addendum here. This is a rather oversimplified criticism, what I have said. Teaching at the graduate level in this country is still the best in the world, and it is because of the emphasis that we put upon research and research as a teaching activity itself. Unfortunately, that same spirit which inspires us at the graduate level does not permeate down to the elementary schools and to the secondary schools. There, teaching becomes a rote exercise without the excitement of new learning, and it is this problem that we need to face up to.

We need to inspire that which is fundamental to all good education. That is, a sense of excitement and the desire to learn. And we discourage that in our lower levels of education and even to some degree in our undergraduate teaching at the college level.

We need to start focusing on how we can remedy that. That is the purpose or the focus of my remarks and the purpose of the legislation that we have before us.

Mr. VALENTINE. Thank you, sir.

Let me recognize Congresswoman Schneider at this time.

Ms. SCHNEIDER. Thank you, Mr. Chairman.

I think there is very little question that one of the greatest challenges that happens to be facing us today is the ability of our work force to compete in the international market place of the future. Increasingly, economic productivity is going to be requiring a population that is infinitely more scientifically literate and technologically capable.

I think that as we look at some of the declines in math and science education, we can pretty rapidly pinpoint the shortage of skilled teachers. Over 1,400 engineering faculty positions happen to be vacant at this time.

We can also point to the deteriorating school and university facilities, and thirdly, to the collapse of the Federal financial support. Unfortunately, the fellowships are down by 78 percent since 1970.

I think that one plainly demonstrated requirement is the need to sustain support for science and math education at every stage of development, and not just have this initiative be a flash in the pan, but rather, one where we are determined that this is going to be a long-term commitment on our part.

First, I think we have to begin in elementary and secondary schools, where an average now of only 18 minutes per day is spent on science in most of the grade schools. It has to continue also into undergraduate and graduate programs. I think that continuing education for adults is something that needs to be emphasized as a way of life so that adults can booster their work productivity.

Another key area, too, is the recruitment of more women and minorities. I would be remiss not to mention the fact that women now comprise half of the U.S. population but account for only 11 percent of the science and engineering work force, and the black and hispanic total is even more demoralizing at 21 percent of the population, earning only 2 percent of all Ph.D's in science and engineering.

If you can believe it, I can top that by suggesting that between now and the Year 2000, women and minorities could provide 85 percent of the new entrants into the work force. Clearly, we know that the writing is on the wall; we know that the challenge is before us. So it is up to us to provide some initiatives and some incentives and encouragement to pursue investments in science, math, and engineering education on an elementary through adult education process.

Because of these concerns, I strongly support and applaud the decision of the subcommittee to seek solutions to these problems. I want to thank you personally, Mr. Chairman, for the opportunity to address these issues at today's hearing.

Mr. VALENTINE. Thank you, ma'am.

Mr. Price?

Mr. PRICE. Thank you, Mr. Chairman. I want to commend you for calling this hearing and commend you and the staff for the work that has been done in pulling together a number of innovative proposals suggested mainly by members of this committee in this draft subcommittee bill, the Science and Technology Education Act of 1990.

These hearings today ought to help us refine this proposal and, I hope, indicate directions in which we should move. So, I look forward to Mr. Bloch's testimony and that of the other witnesses.

Thank you.

Mr. VALENTINE. Thank you, sir.

To those of the Members who were not here when I made the opening statement, I attempted to mention the names of all of the Members, Mr. Buechner, Mr. Price, Mr. Brown, who made a great contribution to this. What we have here is an attempt to pull those several products together and put it into one piece of legislation.

There was mention of the Chairman and the staff, and the Chairman and the staff are in that respect standing on the shoulders of giants.

Mr. Buechner?

Mr. BUECHNER. Thank you, Mr. Chairman. Of course, we are also lucky enough to have some giants from their own fields before us here today.

Mr. Chairman, recently, the Congressional Office of Technology Assessment, the OTA, concluded that a key obstacle in the U.S. shift to an information age economy is the poor productivity of the education sector and in research and development. To help correct this deficiency, I introduced the National Learning Technology Act, which is H.R. 4331 and which is going to be marked up before this committee next week.

According to OTA, the expenditures for capital investment in education, research, and development into new techniques and educational tools are the lowest for any major industry in our country. As a comparison, the United States' average investment is approximately $50,000 per manufacturing job, while educational investment per employee is $1,000.

H.R. 4331 will provide a merit based grant program to the development of materials to enhance the productivity of basic education and advanced instruction. Grants would be awarded by the National Science Foundation to technologies with the potential to make a significant difference in improving elementary and secondary education teaching.

In a world in which technological obsolescence is measured in months instead of years, our education systems are lagging behind the pace. Learning the "Three Rs" or their equivalent is always going to be of vital importance, but given the amount of material the average U.S. student must absorb in order to keep up with other students in the world, it is not enough. H.R. 4331 will improve the teaching process by encouraging the production of education technologies which can help to make the difference for success.

Today, the subcommittee begins consideration of a comprehensive science education package that will, hopefully, mark a new beginning in the future of our education system. I believe that the witnesses we have here today will assist us in this combined endeavor and will offer valuable insights into how the tasks of enhancing our nation's future in science and technical education can be undertaken.

I look forward to the hearing and to reviewing their testimony. A special thanks to you, Mr. Chairman, for calling this hearing today.

Mr. VALENTINE. Thank you, sir.

Mrs. Morella?

Mrs. MORELLA. Thank you, Mr. Chairman. I also appreciate this hearing as the beginning of a series of two hearings on something that is critically important to our nation. That is the whole concept of science and technical education. A lot has been said, and we all realize how important it is to our competitiveness and realize the need to do more to enhance the teaching of math, science, engineering, and coordination of it utilizing the NSF.

I particularly want to comment or associate myself with Congresswoman Schneider's comments about looking at Work Force 2000 and the need to bring in women and minorities who will be entering the work force in greater numbers, to bring them into the science, math, engineering milieu. As a former educator myself, I certainly commend this subcommittee and those people who have been working very hard on coming up with a bill that is going to work.

I look forward to hearing the testimonies today and to being involved in it. Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, ma'am.

[The prepared opening statements of Mr. Costello and Mr. Ritter follow:]

OPENING STATEMENT

BY U.S. REP. JERRY F. COSTELLO

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

JUNE 7, 1990

LEGISLATIVE INITIATIVE FOR SCIENCE EDUCATION

Mr. Chairman, this hearing focuses on a wide-ranging science education bill that would create new grant programs for universities, two year colleges and science museums.

The incorporated parts of several bills would enhance federal efforts to improve science education at all levels. As the United States falls further and further behind other industrialized countries of the world in education, it is important to raise the level of public understanding of issues like the ones before us today. Because of my strong support for these issues, I cosponsored a recent bill that will provide hundreds of new scholarships for young people pursuing the fields of math and science. I look forward to hearing from our distinguished witnesses from all four panels.

Mr. Chairman, thank you for bringing this important hearing to our attention and I anticipate some interesting and relevant commentary by our witnesses.

OPENING STATEMENT
SCIENCE AND TECHNICAL EDUCATION
HON. DON RITTER (R-PA)
JUNE 7, 1990

THANK YOU, MR. CHAIRMAN. AMERICA FACES AN OVERWHLMING CHALLENGE IN SCIENTIFIC AND TECHNICAL EDUCATION. A JOINT NSF/NATIONAL SECURITY AGENCY TASK FORCE ON MATHEMATICS CONCLUDED THAT DEMAND FOR SKILLED SCIENTISTS, ENGINEERS, AND TECHNICIANS IN THE YEAR 2000 WILL EXCEED THE 1986 DEMAND BY 36 PERCENT, NEARLY DOUBLE THE GROWTH IN OVERALL EMPLOYMENT DEMAND.

THE "PIPELINE PROBLEM" IS GETTING WORSE AS THE "BABY BOOM" IS ENDING. BY 1995, THE COLLEGE-AGE POPULATION WILL DECREASE AS MUCH AS 22 PERCENT FROM ITS 1981 LEVEL. ACCORDING TO THE NSF, ONLY 15 PERCENT OF ENTERING COLLEGE FRESHMEN PLANNED TO MAJOR IN THE NATURAL SCIENCES OR ENGINEERING IN 1986, COMPARED TO 20 PERCENT IN 1966. AT THE GRADUATE LEVEL, WE ARE NOT PRODUCING ENOUGH

SCIENTISTS AND ENGINEERS TO MEET THE CHALLENGES OF A COMPETITIVE WORLD ECONOMY.

IN THE ELEMENTARY AND SECONDARY SCHOOLS, THE SITUATION IS QUITE POOR. INTERNATIONAL COMPARISONS OF STUDENT PERFORMANCE IN SCIENCE AND MATH ROUTINELY PLACE AMERICANS TOWARD THE BOTTOM OF THE LIST.

WITHOUT "SCIENCE LITERACY" IN AMERICA, FEWER AMERICANS, ESPECIALLY NON-SCIENTISTS, WILL UNDERSTAND WHAT SCIENCE AND ENGINEERING MEAN TO OUR NATION'S COMPETITIVENESS. AS AN EXAMPLE, "HYPER-REGULATION" MIGHT BE ALLEVIATED IF EVERY AMERICAN LEARNED MORE ABOUT SCIENCE AT SOME POINT IN HIS OR HER EDUCATION.

WE NEED TO RECRUIT AND RETAIN THE BEST TEACHERS IN THE PUBLIC SCHOOLS THROUGH AN APPROACH THAT REWARDS EXCELLENCE AND MARKET FORCES. WE NEED TO ENCOURAGE

INNOVATIVE WAYS OF TEACHING, ESPECIALLY THOSE WHICH EMPHASIZE TEACHING THE ESSENTIAL KNOWLEDGE FOR THOSE WHO WILL MAKE PRODUCTS FOR PEOPLE, AND FOR JOBS. OUR GLOBAL COMPETITORS STRESS THIS AS A MATTER OF COURSE, BUT WE HESITATE TO DO IT. THAT HESITATION MAY COST US DEARLY WHEN WE DON'T HAVE ENOUGH SCIENTISTS AND ENGINEERS IN THE FUTURE.

FINALLY, WE NEED TO DO MORE TO BRING WOMEN AND MINORITIES INTO THE "PIPELINE." CURRICULUM IMPROVEMENTS WILL GO A LONG WAY TOWARD PREVENTING THE "SCIENCE ANXIETY" THAT KEEPS WOMEN AND MINORITIES OUT OF SCIENTIFIC AND ENGINEERING CAREERS.

IN SHORT, THE EDUCATION SYSTEM SHOULD EMBARK ON A "QUALITY REVOLUTION," SIMILAR TO WHAT'S GOING ON IN SOME OF OUR MAJOR COMPANIES SUCH AS XEROX AND FORD...STARTING FROM THE BOTTOM UP, WE NEED TO PREPARE STUDENTS FOR

CHALLENGING CAREERS IN SCIENCE AND ENGINEERING.

OUR SUBCOMMITTEE HAS ASSEMBLED A COMPREHENSIVE BILL, WHICH MAY BEGIN TO ADDRESS SOME OF THE PROBLEMS. I AM PLEASED THAT MUCH OF HOUSE CONCURRENT RESOLUTION 82, WHICH MY COLLEAGUE DOUG WALGREN AND I INTRODUCED LAST YEAR, HAS BECOME PART OF SECTION 2 OF THIS PACKAGE. IN THAT BILL, WE CALLED FOR UNIVERSAL SCIENTIFIC LITERACY AMONG OUR HIGH SCHOOL GRADUATES BY THE YEAR 2000. I LOOK FORWARD TO HEARING FROM OUR WITNESSES ON HOW THE PROGRAMS PROPOSED BY THIS NEW PACKAGE WOULD CONTRIBUTE TOWARD THAT GOAL, AND I WOULD LIKE ESPECIALLY TO WELCOME ERICH BLOCH, WHO IS NO STRANGER TO THIS COMMITTEE, AND A DYNAMIC FORCE IN PROMOTING IMPROVED SCIENCE EDUCATION IN AMERICA.

Mr. VALENTINE. The parade of witnesses today consists of three panels. The first panel is Mr. Erich Bloch, who is the Director of the National Science Foundation, who is here with his colleague Dr. Luther Williams, the new Director of the Education and Human Resources Directorate.

Panel two consists of Dr. Charles Glassick, Vice President, Carnegie Foundation for the Advancement of Teaching from Princeton, New Jersey. Part of that panel was to be Dr. Rosemary Schrare, who is Chancellor of the University of California at Riverside, California, who was unavoidably detained and who will not be with us. Her testimony will appear in the record. On that panel, we also have Dr. Mel George, President of St. Olaf College in Northfield, Minnesota, on behalf of the Associated Colleges of the Midwest, the Great Lakes Colleges Association, The Central Pennsylvania Consortium, and the Allegheny College and Reed College.

Finally, panel three consists of Dr. Phillip R. Certain, Professor of Chemistry, University of Wisconsin-Madison and Science Coordinator, Alliance for Undergraduate Education; Dr. Gordon Nelson, Dean, College of Science and Liberal Arts, Florida Institute of Technology, and Chairman, Education Committee, Council of Scientific Society Presidents; and Dr. Homer A. Neal, Chairman, Department of Physics, University of Michigan at Ann Arbor.

We have just been joined by our colleague from California, Mr. Campbell. We will be happy to hear from you if you have any statement or opening remarks.

Mr. CAMPBELL. I appreciate that, Mr. Chairman. I have no statement at this time.

Mr. VALENTINE. Thank you, sir.

Mr. Bloch, your prepared statement will appear in the record as presented to us. I invite you to summarize if you can conveniently do that. Thank you and welcome to both of you.

STATEMENT OF ERICH BLOCH, DIRECTOR, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY LUTHER WILLIAMS, ASSISTANT DIRECTOR, EDUCATION AND HUMAN RESOURCES DIRECTORATE

Mr. BLOCH. Thank you, Mr. Chairman. I will be quite short with my comments. I hope they serve as a basis for the question and answer session in a few minutes.

Let me begin with the new Directorate for Education and Human Resources that I announced last week and which became effective Monday, June 4th, and as you acknowledged, Dr. Luther Williams joins me here as the new assistant director of that directorate.

Over the past several months, I have devoted considerable personal attention to NSF's Education and Human Resources program, one of our most important missions that is rightfully assigned to NSF. In particular, I have focused on how well we are discharging this mission, especially in view of the increased sense of urgency that has been expressed by Congress, the President, the National Science Board, the science and engineering education community at large, and the public.

Evidences that we are entering a different era with respect to math, science, and engineering education and human resource development abound. Let me just mention a few.

The substantial call for action represented by the national education goals formulated by the President in conjunction with the State governors is one of these. The new and revitalized Federal Coordinating Council on Science and Engineering Technology and the recently established interagency FCCSET Committee on Education and Human Resources is another one. I think it is the first interagency committee that is looking at education and human resources across the Federal Government.

Another is the increased concern expressed by Congress for demonstrable progress and for comprehensive, even radical, approaches to achieve the President's education goals. There is the frequently cited Office of Technology Assessment report in which there is an explicit call for a pipeline or continuum approach to science and engineering education and a specific reference to the need to revise and consolidate the organization of education and human resource activities at NSF.

Others are the formal coordination between NSF and the Department of Education, at the behest of this committee, for programs in math and science education and the perception held by some members of the science and engineering communities that there is a lack of synergism between the Foundation's research and education programs. In these considerations, I am grateful for the substantial progress that we have made in the recent past.

The era between 1983 and today can only be characterized as one of major achievements in the reestablishing of the mathematics, science, and engineering education and human resource programs of the Foundation, especially in the precollege area, but not only in the precollege area. It also includes the undergraduate area and special programs for minorities and the disabled. Personally, I want to commend here in front of this committee Dr. Bassam Shakhashiri for his committed leadership of the Science and Engineering Education Directorate all during this rebuilding phase since 1984.

However, our previous accomplishments notwithstanding, NSF is now challenged, quite appropriately, to exert the leadership to leverage our resources to promote more comprehensive and effective programs and to consolidate our education and human resource activities. Our approach is to address a process of education as a continuum starting at the elementary and secondary levels, in fact, starting at the informal education level, and continuing on through the undergraduate and graduate levels and beyond.

Each level presents different needs and unique opportunities. The transitions between levels are also important and they require attention.

We need to do more than simply improve the quality of the educational experience. We need to pay attention to participation at all levels, especially by underrepresented groups. We need to do a much better job of recruiting and retaining in science and engineering those groups currently not well represented. I mentioned them before.

This new organization, the Education and Human Resources Directorate, is designed to satisfy these new requirements. Specifically, we expect the following benefits to result: greater involvement of the research programs in the area of education and human resource development, especially at the undergraduate level and in the human resource area; a more visible and better coordinated approach to the issues relating to undergraduate education; a more effective outreach and human resource program at all levels; a Foundation-wide policy planning and evaluation process in this area; a single locus for program planning, budget preparation, program evaluation in the process of education and human resources; and the full realization of NSF's national leadership role in establishing the resources and strategy for meeting the Nation's needs for world class mathematics, science education, and technical manpower.

The new directorate will include four functional areas: precollege math and science education and informal education, including teacher preparation and enhancement, materials development, research, and informal education. The second area is human resource development, including programs for women and minorities and persons with disabilities, and research career development. Third is a strong program evaluation component, and fourth is a course directed at science and education coordination, particularly at the undergraduate level.

We are fortunate to have at NSF an executive with strong qualifications in both the education and human resources areas to serve as the new Assistant Director of EHR, Dr. Luther Williams, who you met a few minutes ago. Let me stress that the result of these changes in administrative structure will be to strengthen and improve the coordination of the Foundation's education and human resources activities, both internally and from an interagency perspective, and to elevate the visibility of this very important area. The existing SEE organization that existed until this week has remained intact.

The new directorate has even broader management responsibilities than its predecessor, bringing in the special programs relating to women, minorities, and persons with disabilities, previously located in the Directorate for Scientific, Technological, and International Affairs. The Assistant Director for EHR, Dr. Williams, will serve as Chairman of the NSF Education and Human Resources Policy Committee of the National Science Foundation. In that role, he will be responsible for strengthening the management and oversight of a number of undergraduate educational activities administered directly by NSF's research programs and for Foundation-wide planning in these areas.

With respect to the draft legislation before the committee, Mr. Chairman, my prepared statement spells out the Administration's views, namely that we do not need new legislative authority. We are pleased to discuss with you new ideas for relative emphasis on various types of activities. However, nearly everything in the bill before us is achievable under our current laws, authorization, and programs.

Let me add that the new management structure that we have put in place at NSF reflects the widespread realization that the

Nation needs to move away from stand-alone programs addressing a limited set of objectives toward a broader, more comprehensive approach. While we must remain flexible in the design, operation, and management of our programs, we want to be guided by a set of long-range strategic objectives in the areas of math, science, and engineering education and human resource development.

In closing, let me reiterate my view that NSF has recognized and has responded to the need to give higher priority to education and human resources. Since 1987, that component of our budget has increased by 250 percent, thanks in part to the actions and support of this committee. I know that we can count on the committee's continued support for our activities in this area.

I want to compliment you, Mr. Chairman, and compliment the committee for your focus on this very important area. I certainly appreciated some of the opening comments, especially Mr. Brown's, with which I strongly identified.

I would also ask that Dr. Williams statement be entered into the record. We are both glad to be here and stand willing to answer your questions.

Thank you.

[The prepared statements of Mr. Block and Dr. Williams follow:]

ERICH BLOCH

DIRECTOR, NATIONAL SCIENCE FOUNDATION

TESTIMONY

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

JUNE 7, 1990

Mr. Chairman, I appreciate the opportunity to testify before this Committee on the subject of science, mathematics, and engineering education. At a time when this Nation is facing many pressing problems with respect to its economic competitiveness, the development of a scientifically skilled workforce and a scientifically literate public is vital to meeting the challenges of technological change and a knowledge-intensive global economy.

I particularly want to commend this Committee for its strong and consistent support for basic research and for its interest in the broad range of issues, including education and training, that affect the productivity of our research system and the competence of our science and engineering workforce.

Education and Human Resources: A National Concern

Since this Committee is well-acquainted with the status of science, mathematics, and engineering education in this country, I need not dwell in detail on the problems we face. However, it is important to stress that these problems are not limited to one stage of the educational process; they pervade all levels. We have serious problems at the precollege level, both in terms of the quality of instruction and the quantity of students interested in science and mathematics. International comparisons of the performance of students in the sciences and mathematics routinely place Americans toward the bottom of the list.

Student interest in the sciences and engineering has also been declining at the undergraduate and graduate levels. Demographic trends are likely to aggravate this situation through the beginning of the next century. The college age population is declining. Equally important, women and minorities -- two groups with historically low participation rates in the sciences and engineering -- are becoming larger parts of the labor force.

Roles and Responsibilities

The Nation's educational system is diffuse and decentralized, with primary responsibilities located at the state and local levels. It is, therefore, at the state and local level that our national effort must be directed. Nevertheless, as was made clear at the recent education summit between President Bush and the governors and reaffirmed at the meeting of the National Governors' Association in February, our success in improving the performance of our students depends on contributions from all institutions -- state, local, and Federal; public and private. It also depends on a commitment to excellence in achievement on the part of every parent, teacher, administrator, and student.

President Bush and the governors have challenged the Nation with an ambitious goal for science and mathematics education:

> "By the year 2000, U.S. students will be first in the world in science and mathematics achievement."

Achieving this goal will require a fundamental transformation of our assumptions, our strategies, our habits, and, indeed, our culture to produce a durable transformation of the educational process, a transformation that must emphasize excellence, coherence, and continuity.

Throughout the Nation, there is understandable frustration at the pace with which education reform is realized. However, "quick fixes" that fail to take into account the complexity and diffuseness of our educational system and the necessary involvement of the Federal, state, and local governments, parents, local school boards, businesses, and communities are suspect, not desirable, and not believable.

The National Science Foundation is strongly committed to exercising strong leadership to improve the science and mathematics competence of our students and to increase the size and quality of our scientific workforce. NSF performs a unique and strategic role in this area. It is charged with improving and strengthening the national capacity for research in the sciences, mathematics, and engineering. NSF has a similar charge with respect to excellence in science, mathematics, and engineering education. This includes the responsibility to monitor the health and quality of our achievement and performance in these areas.

NSF's dual mission in research and education underscores the interdependence of research and education in this country, a unique arrangement that has resulted in the development of an enormously creative and productive academic enterprise. Our research and education programs are pursued, therefore, in a complementary and synergistic manner. Specifically, our educational mission includes:

(a) precollege mathematics, science and technology education;
(b) undergraduate science, mathematics, and engineering education;
(c) maintenance of the science and engineering (S&E) personnel essential to the Nation's research capabilities through graduate fellowships and post-graduate activities; and
(d) support for other components of the S&E process, including broadening participation by underrepresented groups and institutions.

The development of our scientific talent and the enhancement of science literacy are NSF's highest priorities. NSF programs are designed to address both qualitative and quantitative deficiencies manifest at all critical points in the educational process.

NSF activities are based on the premise that high-quality education in science, engineering, mathematics, and technology must be available at every educational level. Only in this way can we prepare all students for citizenship in an increasingly technological world and enable them to make intelligent choices about their own advanced studies and careers.

NSF's role is to provide leadership and expertise and to serve as a catalyst in a national effort to introduce changes and improvements to our educational institutions. Our efforts in education are designed to be highy leveraged, to serve as models and examples for replication, and to encourage cooperation among all who play a role in the educational process. The Foundation focuses its energies on initiatives of special importance and high merit, drawing on the advice and expertise of a broad community of scientists, educators, and administrators from all levels of the educational process.

History and Policy

To place NSF's current efforts in context, a historical perspective is in order.

In 1982, a decision was made to phase out most of NSF's programs in precollege mathematics and science education, based on a perception that many of these programs were unfocused. As a result, NSF educational support was limited primarily to the graduate level, while the FY1982 budget for precollege education dropped to $3.8 million. [See Appendix 1.]

At the same time, it became clear that the Nation's need for an increasingly scientific and technical workforce called for a vigorous and well-reasoned plan to improve education in the sciences, mathematics, and engineering at all levels. NSF, through the National Science Board's Commission on Precollege Education in Mathematics, Science and Technology, developed an action plan in September 1983, "Precollege Education in Mathematics, Science and Technology." This call for action, one of the first to address the needs at the precollege level, was followed by another National Science Board report in 1986, which provided an explicit program plan for undergraduate science, mathematics, and engineering education.

NSF's Long-Range Plan for the period of FY89-93 and the Strategic Plan for FY90-94 articulated the basis for Foundation programs in science and engineering education. The latter action plan, "Enhancing the Quality of Science, Mathematics, and Engineering Education in the United States," stipulated the following policy and objectives:

- Expanding excellence in science, mathematics, and engineering instructions at all levels, and encouraging higher expectations of student and institutional performance;
- Developing attractive and effective new courses and curricula that provide consistent and coherent mathematics and science alternatives for consideration by those who administer education programs;
- Increasing the effectiveness of new teachers, faculty members, and supervisors;
- Developing the means for lowering science and mathematics avoidance rates of female, minority, and disabled students, while stimulating their interest in scientific and technical careers; and
- Increasing the number of university faculty and researchers who give attention and effort to the improvement of science, mathematics, and engineering education, not just at the undergraduate level, but also, and particularly, at the precollege level.

NSF Establishes Directorate for Education and Human Resources

On June 1 of this year, NSF announced its plans to strengthen its support for science, mathematics, and engineering education by establishing a new Directorate for Education and Human Resources (EHR). The Directorate will have broad responsibility for managing all of NSF programs in education and human resources, from pre-college and informal science education activities to undergraduate and graduate training and beyond. All existing programs in the former Science and Engineering Education (SEE) Directorate will be maintained, while programs for women, minorities, and the disabled will be relocated from elsewhere in the Foundation to the new EHR Directorate. This reorganization will undoubtedly improve coordination and management of the Foundation's entire science education enterprise as well as its working relationships with other agencies and state and local government. The changes are consistent with recommendations made by a variety of groups, including the congressional Office of Technology Assessment in its report "Educating Scientists and Engineers: From Grade School to Grad School."

Dr. Luther Williams, formerly Senior Science Advisor for the Foundation, has been named the Assistant Director for the newly created Directorate. In his new capacity as Assistant Director for EHR, Dr. Williams will serve as Chairman of the NSF Education and Human Resources Policy Committee, with responsibility for Foundation-wide planning in the EHR area and for the disciplinary research programs. Dr. Williams, former President of Atlanta University, is a leader in efforts to improve educational opportunities for minority students. Dr. Williams served as Director of the Minority Center for Graduate Education at Purdue University from 1977-80 and as member of the White House Advisory Committee on Historically Black Colleges and Universities and the the U.S. Government Task Force on Women, Minorities, and the Handicapped in Science and Technology. Dr. Williams is also Vice Chair of the Committee on Education and Human Resources, a new committee created under the auspices of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET).

NSF Activities in Education and Human Resources

Since 1982, the National Science Foundation has dramatically increased support for education at all levels, from $34 million in FY1982 to $357 million in FY1990. [See Appendix 2.] During this period, education and human resources (EHR) increased from 3 percent to 17 percent of NSF's total budget. For FY1991, NSF has requested a 30 percent increase for EHR to $463 million. EHR is, in fact, the fastest growing part of NSF's budget and currently accounts for 20 percent of the Foundation's entire budget. Even though NSF as a whole received only half its requested increase for FY1990, science education grew by 23 percent over the FY1989 level. As a result of these increases, the number of students supported by NSF at all levels has about tripled since 1983. [See Appendix 3.]

These increases for science and engineering education are significant not only for NSF, but within the broader Federal context as well. In the President's FY1991 budget, NSF represents about 45 percent of the total Federal investment in programs specifically targeted on science and engineering education and human resources. While the Administration has a commitment to double NSF's overall budget by 1993, the educational portion of the budget would be tripled by that year.

Strategy

The overall perspective that guides NSF is that the educational process is a series of interdependent and interconnected stages, with links from pre-school through Grade 12, to undergraduate and to graduate study. NSF's efforts to recruit and retain students in science, mathematics, and engineering education must recognize the inherent differences and needs that exist within each educational level as well as its relationship to and impact on other grade levels.

NSF's overriding goal is to insure that the educational process stimulates the interest of students in the sciences and engineering, thereby assuring that the Nation has the scientists and engineers, the scientifically literate workforce, and educated public it needs for the decades ahead.

NSF programs are designed to be catalytic and to leverage the finite resources available. They are also designed to address specific problems, opportunities, and needs central to the improvement of science, mathematics, and engineering education and training of students, teachers, and faculty at all levels. An important aspect of NSF's programs is their special emphasis on underrepresented groups, institutions, and localities, such as urban school districts, that require special focus and support.

Programs: Support at all Levels:

NSF programs are significant not just for the level of their commitment but also for the breadth of their support for the attraction and retention of students in all levels of the educational process. [See Appendix 4.]

Precollege level:

NSF's efforts at the precollege level are designed primarily to attract more students into science education while improving the quality of their exposure to math and science overall. Toward this end, NSF programs are designed to provide enrichment activities for students, bolster elementary and secondary instruction, support informal education programs, and reinvigorate elementary and secondary science and math education. [See Appendix 5 for a full description of these programs.] These programs, it should be noted, serve all students, not just those who will pursue majors and careers in mathematics, the sciences, or engineering.

NSF has put in place programs to enrich and reinforce the interest of high school students in science and mathematics.

Our Young Scholars program annually provides some 5,000 students with real research experiences to stimulate their interest in science and mathematics and to help prepare them for college.

NSF also seeks to bolster precollege instruction by improving the quality of precollege teaching and teaching materials. NSF has refocused its Teacher Preparation and Teacher Enhancement programs to reach greater numbers of teachers. Teacher support networks have been established to improve interaction with practicing scientists and engineers. Alliances among local teachers and schools, scientists and engineers, and colleges and universities have been created through the Private Sector Partnerships Program. Today, NSF programs are improving the subject matter competence of 12,000 elementary and secondary level mathematics and science teachers annually. Finally, through the Presidential Awards program, NSF recognizes the Nation's very best elementary and secondary mathematics and science teachers, thus enhancing the status of the entire profession. Support for these activities has increased from $1.1 million in FY1983 to $25.0 million in FY1985, $63.7 million in FY1989, and a requested $89.0 million for FY1991.

The quality of teaching also improves with the quality of new instructional materials. NSF has put in place new programs to improve the materials and curricula used to teach science and mathematics at the elementary and secondary level. NSF is also supporting the use of innovative advanced technologies to improve the effectiveness and outreach of science education programs.

Through the Informal Science and Mathematics Education Program, NSF is also effectively encouraging the publishing industry to contribute resources and to work with schools, school districts, and curriculum development teams all across the Nation. The dissemination of these new materials to school systems needs to be improved. NSF's renewed coordination with the Department of Education ensures increased dissemination of these materials through the Department's National Diffusion Network. The NSF FY1990 budget for this activity represents a doubling of the FY1986 level.

NSF is creating a new program to reinvigorate elementary and secondary education by pursuing broad-based, fundamental changes at the State and local levels. The Statewide Systemic Initiative program, recently announced in conjunction with the National Governor's Association, will complement NSF's ongoing efforts in science education. In order to bring about major educational reform, NSF will work with States to plan and design activities that only the States can implement. These activities will, quite appropriately, build on many of the NSF-supported teacher training and curriculum development projects that are currently yielding positive results. More importantly, the States Initiative will catalyze the systemic, comprehensive changes necessary for major improvements in the teaching and learning of science and mathematics at all educational levels. The program will involve teachers, the business community, state and local education entities, Federal research laboratories, as appropriate, and, in particular, the Department of Education's Eisenhower Program.

Urban areas are a point of special attention, because of the heavy concentration of population, and of minorities in particular. Our future success in the educational area will be heavily influenced by our ability to make positive impacts in urban schools.

It will, however, be up to the individual States to decide how they can best put together a meaningful reform effort, given the various factors that affect a particular State's educational system. It should be emphasized that the general flexibility and lack of prescription attending the congressional authorization of NSF programs permits the implementation of the Statewide Systemic Initiative. This flexibility enables NSF to stimulate and encourage comprehensive and systemic reforms in strategic and innovative ways.

Finally, to insure the highest possible effectiveness of its programs, NSF is expanding efforts to improve student, teacher, and program assessment techniques and instruments. NSF regularly encourages states and localities to avail themselves of materials and expertise developed through NSF-funded projects when they establish new standards for curricula and assessment.

As shown in Appendix 5, these are some of the pieces of NSF's total effort in elementary and secondary mathematics and science education. They represent only part of NSF's strategy. Collectively, these programs emphasize stimulating and supporting comprehensive changes in the Nation's educational systems. In its efforts to take a strategic approach, NSF experiments with and supports a wide range of activities that show promise for addressing important aspects of the problem. That is why NSF is investing in diverse projects ranging from teacher training to materials development, from research experiences for students to science enrichment opportunities and informal education, including science museums, television programs like Square One, 3-2-1 Contact, and other modes of informal mathematics and science education.

Undergraduate education:

NSF's efforts in undergraduate education are designed both to recruit and to retain students in science, mathematics, and engineering education. Like its precollege programs, NSF's undergraduate programs are characterized by their comprehensiveness. All NSF Directorates participate in efforts to forge mutually enriching relationships between education and research. Some programs are funded and managed entirely in the research directorates; others by the Science and Engineering Education Directorate. All are coordinated by the Science and Engineering Education Directorate's Division of Undergraduate Science, Engineering, and Mathematics Education. NSF's total effort in undergraduate education is $90 million in FY1990, with a 48 percent increase to $134 million requested for FY1991.

NSF's programs serve a number of purposes: to make research experiences available to undergraduates; to facilitate the acquisition of research instrumentation to improve undergraduate laboratory instruction; to enhance faculty competence; and to improve courses and curricula for all students, not just those intending to pursue scientific careers.

These programs serve not only four-year and doctoral institutions, but two-year and community colleges as well. These institutions participate directly in NSF programs and use materials developed by NSF curriculum and laboratory development activities.

Graduate level:

At the graduate level, the Foundation's activities are devoted specifically to training technical personnel for the Nation's critical research activities, be they in academia, government, or industry.

- A trio of graduate fellowship programs -- the regular fellowship program, the Women in Engineering program, and minority fellowships -- provides direct support to nearly 3,000 of the Nation's ablest graduate students preparing for careers in the sciences and engineering.
- NSF's research grants support an additional 12,000 graduate students working with principal investigators on research projects.
- At the postdoctoral level, several programs are designed to meet the needs of our universities for qualified faculty.

Programs Focused on Underrepresented Groups:

A critical element of all NSF education and human resource programs is a strong concern for increasing the participation of underrepresented groups, that is, women, minorities, and the disabled, in the sciences and engineering. Demographic trends clearly show that minorities and women will soon constitute a significantly increased portion of the workforce. Without substantial improvements in this area, this Nation will be seriously handicapped in its efforts to recruit and retain the new scientists, mathematicians, and engineers needed to meet the challenges of the highly competitive global economy.

The Foundation has established a number of cross-program efforts to increase the participation the underrepresentation of women, minority, and disabled students in the sciences and mathematics. Two special NSF task forces, one on women and another on minorities, have submitted reports that serve as the basis for our current efforts. A third task force on the disabled will provide a similar basis for activities to encourage participation within this group as well.

Currently, NSF's Career Access Program supports efforts to increase the entry of women, minorities, and the disabled into science, mathematics, and engineering courses and programs and to encourage them to pursue scientific careers. The Career Access Program supports specific prototype projects and the Comprehensive Regional Centers, which are designed to increase the pool of interested and eligible minorities who could become successful scientists and engineers. The Centers are comprehensive in their coverage of science, mathematics and engineering; their coverage of educational levels from elementary school through the baccalaureate; and their emphasis on interaction among cooperating groups and organizations. Other NSF programs that target minorities include Minority Research Centers of Excellence, Research Improvement in Minority Institutions, and Research Careers for Minority Scholars.

Programs to recruit and retain women in research careers include the Research Opportunities for Women program, Visiting Professorships for Women, and the Women in Engineering program.

Two new programs included in the FY1991 request will further strengthen NSF efforts with respect to underrepresented groups. Faculty Awards for Women will recognize and support outstanding women in science and engineering. The Alliances for Minority Participation program, which focuses on problems such as retention, support, and inadequate student preparation, will encourage undergraduate minority students to complete their baccalaureate degrees and pursue graduate studies in science and engineering.

Partnerships and Leveraging:

Cooperation among various institutions will be critical to success in bringing about a fundamental reform in science, mathematics, and engineering education. Cooperative arrangements have been built into many NSF programs. The success of the Statewide Systemic Initiatives program, for example, rests entirely on collaborative partnerships among States, localities, academia, the private sector, and the federal government.

Two other examples of NSF programs that stress cooperation are the Career Access Program and the Alliance for Minority Participation program. In particular, the Alliances program, to be initiated in FY1991, grew out of a realization that a more strategic approach is needed to attract significantly larger numbers of minorities into science and engineering. No single institution, be it higher education, industry, or the private sector, is capable of addressing this problem alone. There is a need for a collaborative effort among all of these participants. NSF's Alliances program will support efforts to increase the numbers of minority undergraduate and graduate S&E degrees by forming explicit partnerships between NSF and other sponsors, including other Federal agencies, S&E industries, private foundations, and higher education institutions.

The importance of cooperation pervades NSF programs at all levels. Industrial participation has been a significant feature of the Publisher's Initiative, the prestigious Presidential Young Investigators program, and undergraduate and graduate educational programming at the Engineering Research Centers and the Science and Technology Centers.

Cooperation within the Federal Government:

As is clear from the orientation of all NSF efforts in science and engineering education, cooperation between the Federal Government and universities, industry, the states, and local communities, is critical to the success of the entire strategy. It is also an important objective within the Government and among Federal agencies.

The National Science Foundation and the Department of Education have been working together to improve coordination. The purpose of these meetings is to identify specific agency strengths and responsibilities, to recognize differences in our missions, programs, and relationships with other sectors of society, and to focus on areas of mutual interest. In March, Dr. Allan Bromley, Assistant to the President for Science and Technology, released a congressionally-mandated report on coordination between NSF and the Department of Education. That report spells out a series of specific areas of formal coordination that NSF has established with the Education Department. On an informal level, Secretary Cavazos and I have joined with Dr. Bromley to pursue discussions on how NSF might assist the Department of Education in the reauthorization of its mathematics and science programs.

While NSF and the Department of Education have well-established roles in science and engineering education, other agencies have significant contributions to make as well. NASA and the Department of Energy are responding to the need for a comprehensive national effort by increasing their focus on education. Interagency coordination will be improved by the new FCCSET Committee on Education and Human Resources. The Committee will work to reduce program overlap, identify areas of need, and develop a truly integrated interagency effort in mathematics and science education. The Committee, created by White House Science Advisory and FCCSET Chairman D. Allan Bromley, is chaired by Secretary of Energy James Watkins, with vice-chairmen Ted Sanders, Undersecretary of Education, and Luther Williams, Assistant Director of NSF for Education and Human Resources.

Role of Congress:

Congress has been highly supportive of improving science and engineering education in this country. The consequences of this commitment are clearly visible in the strong increases in NSF's budget for education and human resources.

Congress can further contribute to this process by improving coordination among committees with oversight responsibilities for mathematics and science education, and by paying closer attention to the strengths of the respective agencies as the basis of their own programs and of cooperative activities. One of the most important contributions Congress can make is to preserve the Foundation's flexibility to innovate and to pursue excellence. This has been fundamental to the effectiveness of its programs. Flexibility must be preserved and encouraged to ensure continued success and innovation.

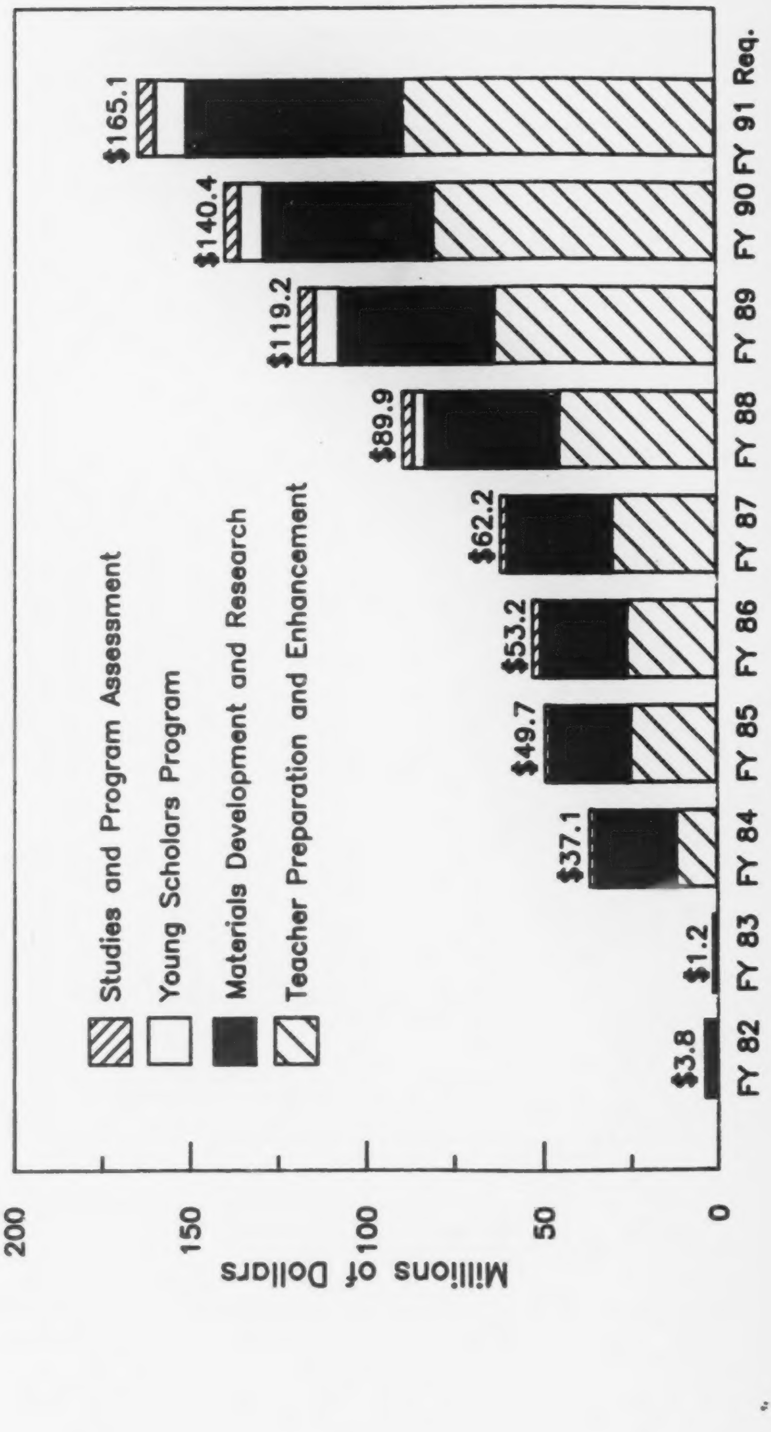
Draft Bill on Science Education

The Committee's letter of invitation asked for NSF to focus on the draft bill the subcommittee is now considering. At this point in time, Mr. Chairman, as my testimony has made clear, NSF, the Department of Education, the Department of Energy, and others are pursuing an extensive and coordinated math and science teaching and learning strategy. We do not need new legislative authority. We are all pleased to discuss with you ideas for relative emphasis on various types of activities. However, nearly everything in the bill before us is achievable under our current laws or programs. The Nation needs us to work closely together -- the agencies and the Congress.

Thank you, Mr. Chairman. I will be happy to answer any questions you may have.

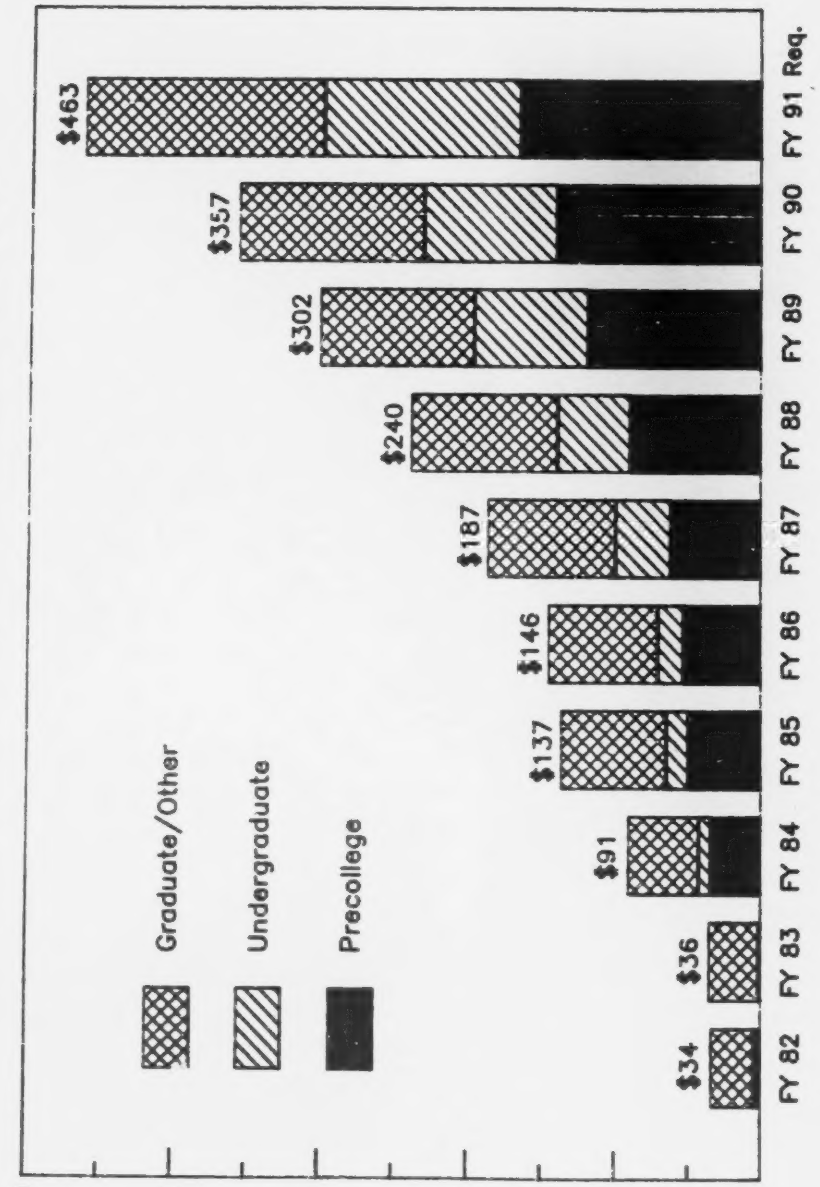
Appendix I

National Science Foundation
Precollege Activities, FY 1982 – FY 1991



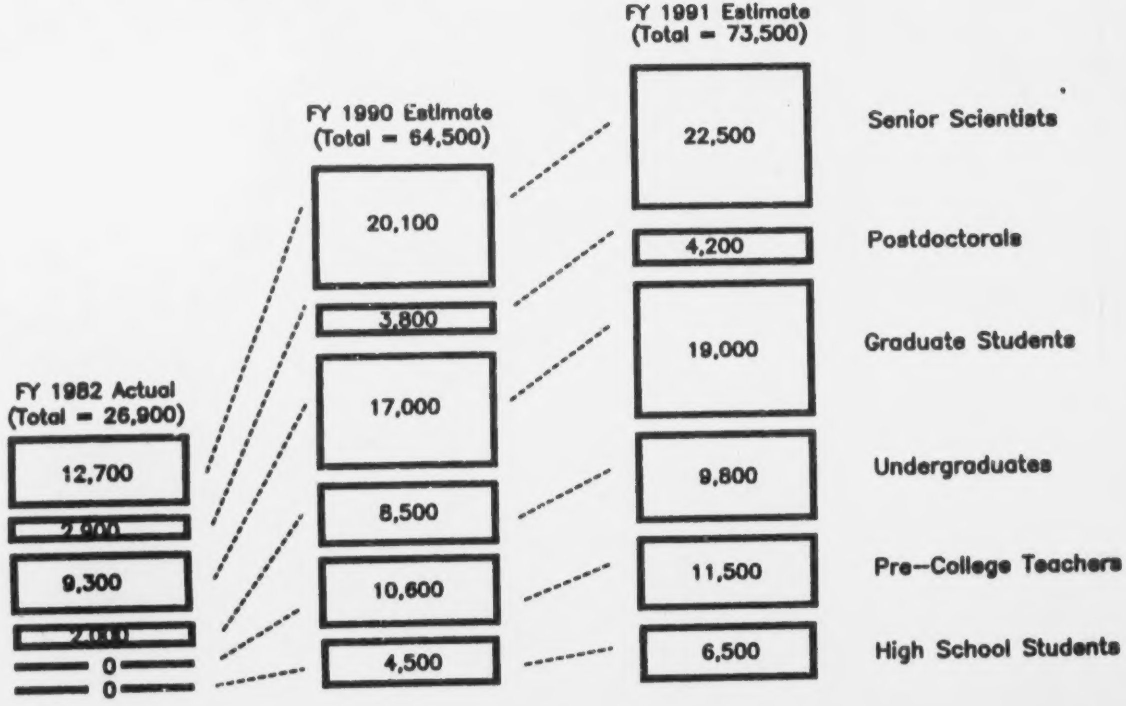
Appendix 2

National Science Foundation Education and Human Resources



Appendix 3

NATIONAL SCIENCE FOUNDATION SUPPORT FOR HUMAN RESOURCES



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Appendix 4

EDUCATION AND HUMAN RESOURCES THEME
(COMPONENTS)

Program	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89	FY 90 PLAN	FY 91 REQ
PRECOLLEGE										
Teacher Preparation	0.0	1.1	11.9	25.2	26.2	30.5	45.4	63.7	81.0	89.6
Material Development & Research	3.8	0.1	23.4	22.7	24.3	29.5	37.6	44.0	48.0	61.5
Studies and Policy	0.0	0.0	1.8	1.8	2.7	2.2	3.2	4.5	4.4	5.0
Assessment	0.0	0.0	0.0	0.0	0.0	0.0	3.6	7.0	7.0	9.0
Young Scholars										
Subtotal	3.8	1.2	37.1	49.7	53.2	62.2	89.9	119.2	140.4	165.1
UNDERGRADUATE										
Research in Undergraduate Institution	0.0	0.0	6.7	8.8	10.7	14.6	15.9	18.6	14.9	14.9
Instrumentation and Laboratory Improvement	0.0	0.0	0.0	5.0	5.3	9.5	11.5	23.2	22.3	26.3
Course and Curriculum	0.0	0.0	0.0	0.0	0.0	0.0	3.0	6.9	16.3	35.5
Research Experiences for Undergraduates	0.0	0.0	0.0	0.0	0.0	11.9	10.4	14.1	14.2	14.5
Research Careers for Minority Scholars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	3.9	9.3
Faculty Enhancement	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.1	3.3	4.3
Alliances for Minority Participation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8
Career Access	0.0	0.0	0.0	0.0	0.0	0.0	2.5	5.1	11.9	15.6
Other	0.0	0.0	1.5	1.5	1.5	1.5	3.2	4.4	3.7	3.3
Subtotal	0.0	0.0	8.2	15.3	17.5	37.5	49.5	77.4	90.5	134.2
GRADUATE FELLOWSHIPS	15.0	15.0	20.3	27.3	26.1	27.3	30.3	24.0	29.2	35.9
[Minority Grad]				[2.7]	[2.6]	[2.9]	[3.0]	[2.4]	[4.5]	[5.4]
NEW INVESTIGATOR INITIATIVES	0.0	0.0	8.9	17.1	24.9	33.9	40.9	49.3	49.5	60.8

Apnendix 4 (cont'd)

EDUCATION AND HUMAN RESOURCES THEME
(COMPONENTS)

Program	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89	FY 90 PLAN	FY 91 REQ
WOMEN/MINORITIES (Targeted programs)										
Visiting Professorship For Women	0.9	1.9	2.1	2.1	2.1	2.0	2.3	2.3	2.3	2.7
Research Opportunities For Women	0.0	0.0	0.0	2.6	2.0	2.5	2.6	2.9	3.2	3.5
Faculty Awards-Women	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
Women in Engineering	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.5
Minority Research Initiation	1.4	2.0	2.5	2.6	3.0	2.7	2.9	3.1	3.4	3.8
Research Improvement in Minority Institution	0.9	2.0	2.5	5.0	5.0	5.0	5.0	5.0	4.8	5.0
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Subtotal	3.2	5.9	7.1	12.3	12.1	12.2	12.8	13.3	14.4	21.5
EPSCoR	3.0	2.5	0.2	1.0	2.0	4.0	6.0	8.1	9.8	9.8
OTHER										
Policy Research and Analysis	3.9	4.3	4.6	5.1	1.8	1.8	0.9	0.9	0.8	0.9
Science Resources Studies	3.1	3.7	4.2	4.1	3.9	3.9	4.0	4.3	5.0	5.0
Global Change Educ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1
Res Training Groups	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	5.3
Special Postdocs & Other	2.2	3.0	3.5	5.0	4.0	4.0	5.0	5.0	13.8	15.5
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	9.2	11.0	12.3	14.2	9.7	9.7	9.9	10.2	23.6	35.8
	======	======	======	======	======	======	======	======	======	======
TOTAL EHR	$34.2	$35.6	$94.1	$136.9	$145.5	$186.8	$239.2	$301.4	$357.4	$463.1
Percent of NSF Budget	3.4%	3.3%	7.2	9.1%	10.0%	11.5%	13.9%	16.0%	17.2%	19.4%

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Appendix 5

NATIONAL SCIENCE FOUNDATION

The National Science Foundation is committed to providing strong and continuing leadership in addressing the complex predicament of science, mathematics, engineering, and technology education. Specifically, our education mission includes:

(a) precollege mathematics, science and technology education;
(b) undergraduate science, mathematics, and engineering education; and
(c) maintenance of the Science and Engineering (S&E) personnel essential to the Nation's research capabilities; and
(d) other components of the S&E pipeline, including broadening participation by underrepresented groups and institutions.

The overall strategy that guides our efforts is to impact critical stages of the educational pipeline, while strenthening linkages from pre-school through Grade 12, to undergraduate and to graduate study. All the links must be strong. The actions we take to influence the educational process at each level must recognize the inherent differences and needs that exist within each level. Our programs, as with any endeavor, are limited by a finite amount of resources, but they are designed to be catalytic and leverage these resources. They are also designed to address specific problems, opportunities, and needs inherent in improving the mathematics, science, technology and engineering education and training of students, teachers, and faculty at all levels. The over riding goal NSF has set is to stimulate the interest of students in order to ensure that the Nation will have the scientists and engineers it needs for the future and the technically literate workforce and educated public we require as we enter the 21st century.

Under the rubric of this overall strategy, NSF's education policy and objectives are as follows:

- Expanding excellence in science, mathematics, and engineering instructions at all levels, and supporting the acceptance of higher expectations of students and institutional performance;

- Developing attractive and effective new courses and curricula that provide consistent and coherent mathematics and science alternatives for consideration by those who administer education programs;

- Increasing the effectiveness of new teachers, faculty members, and supervisors;

- Developing means for decreasing the science and mathematics avoidance rates of female, minority, and disabled students, and increasing their interest in scientific and technical careers; and

- Increasing the number of university faculty and researchers who give attention and effort to the improvement of science, mathematics, and engineering education, especially at the precollege but also at the undergraduate level as well.

The programs described herein are representative of our strategy and consistent with the discrete program objectives for precollege, undergraduate and graduate levels of sciences, mathematics, engineering and technology education, as appropriate.

I. PRECOLLEGE MATHEMATICS AND SCIENCE EDUCATION PROGRAMS

NSF's precollege effort comprises eleven programs. The titles of these programs employ conventional terms, but the programs themselves and the projects they support are innovative and imaginative. Here, the brief description of each program is followed by a single example of a project being supported by it. Except for the absence of a program that addresses institution and system needs related to physical facilities, this set of NSF activities deals with all of the major elements of education -- all the people, and all the institutions.

1. The Teacher Enhancement Program provides support for model projects for in service improvement of the qualifications and effectiveness of mathematics and science teachers. There are hundreds of projects under this program and they reach virtually into every corner of the country. There are city projects and country projects; school projects and museum projects; and large school projects and small school projects. The projects cover a broad spectrum of characteristics and many of the more successful are attracting imitators -- which is what is supposed to happen with model projects such as these. **The program will serve more than 13,000 teachers in FY 1990.**

> One such project is the "Summer Institute for Science and Mathematics Teachers at Fermilab." Sixty high school biology, chemistry, physics, and mathematics teachers rubbed shoulders with some of the best scientists in the world (Fermilab hosts scientists from 18 countries). In an environment filled with the creation of new knowledge, these teachers were brought up to speed on both subject matter and teaching methodologies.

2. The Teacher Preparation Program supports innovative projects in the preservice education of future teachers of mathematics and science that address expert-identified shortfalls in the content of teacher education and the intense problems in the profession

that will arise because of current demographic trends. **The FY 1990 projects will provide for a steady-state production of approximately 1,300 teachers per year. The FY 1990 budget for the Teacher Enhancement and Teacher Preparation programs is $81 million.**

> "A Model Program for Preparing Middle School Mathematics Teachers" is in its fifth year at Illinois State University. The project has involved a major reconceptualization based on the premise that learning mathematics is a constructive process requiring actively-facilitated problem-solving experiences. The curriculum includes innovative work in topics such as probability and statistics, mathematical modeling, geometry, calculus, and abstract algebra, and covers a well developed set of induction year activities. **Over a hundred students graduate from the program each year.** They have unusual depth in mathematics and parallel sensitivity and skill in teaching middle school students.

3. The Science and Mathematics Education Networks Program supports local or regional groups organized to share information, resources, and/or talent in service of a general or specific educational objective -- often, the improvement of some aspect of the delivery of educational service. **Nearly 1,800 teachers will be served by this program in FY 1990.**

> An example of the flexibility of the Networks Program is its support under its "private sector partnerships" sub-program of "Placement of Retired Professionals in Secondary Schools for Teaching Science and Mathematics," a project of the National Executive Service Corps. Through this experimental project, retired scientists and engineers are recruited through their professional societies to serve as volunteers in the schools of Baltimore, after appropriate training and orientation. They work under guidance of school system personnel. Their performance is carefully monitored and evaluated. The record of the project will be used to prepare a "How To" book for dissemination to schools, professional societies, and businesses outlining successful procedures which could be replicated elsewhere.

4. The Presidential Awards in Science and Mathematics Teaching program is designed to demonstrate the importance of good teaching by explicitly recognizing and rewarding each year the excellence achieved by some science and mathematics teachers. Each awardee is provided with modest resources for future use and becomes part of a national network of excellent teachers.

> **During the first six years of its existence, this program recognized the achievements of one science teacher and one mathematics teacher from the secondary schools of each state.** Beginning with FY 1990, science and mathematics

teachers from the elementary schools of each State will be honored similarly. These outstanding teachers exchange information about their successful programs during a week's visit to Washington, DC; afterwards they join the extensive networks of previous award winners in bringing their influence to bear on the improvement of mathematics and science education in every part of the United States.

5. The Instructional Materials Development Program supports the development of many kinds of instructional materials (in projects that range from those dealing with a few modules at a single grade level to others that are preparing new model curricula covering as many as six school years) in mathematics and science that promote the mathematics and science literacy of students at all grade levels and build a sound background for disciplinary learning in both high school and college.

One of the components of the Foundation's Instructional Materials Development Program is the NSF Publisher Initiative. Its individual projects involve three-way "triad" partnerships of publishers, schools and school systems, and academic curriculum development teams. Through the "triad projects," **NSF has undertaken an integrated, large scale effort in support of the development of a group of "base-line" curriculum packages designed to provide high-quality science curriculum alternatives for elementary and middle schools.** These alternatives are sequences that are appropriate for use by all students in typical school systems. They are specifically designed, developed, and marketed with the intent of reaching students whether or not they enter the learning setting with a strong interest in science.

An example is: "SUPER SCIENCE," a project of Scholastic, Inc., for grades 1-6. This is a mass media science project centered on the development of a pair of monthly magazines -- one for students in grades 1-3, another for use in grades 4-6. The magazines include readings, activities, and illustrations related to a variety of science topics. Each includes charts and teacher's guide materials. The magazines are designed to meet teacher concerns that their textbooks are outdated and that it is difficult to expose students to or to involve them in enough hands-on activities and investigations of science. **After two years of development, Super Science was being used by 575,000 students in December 1989.** The circulation target for that date was 300,000. **Before the grant period is concluded, over 1,000,000 students are expected to read each issue.** Through Super Science large numbers of students are becoming involved in hands-on science investigations for the first time; the magazines are enhancing reading among students who are reading below grade level. Teachers using Super Science find that the science content in the magazines is improving levels of reading comprehension. The evaluation also found that about half the pilot teachers in "Triad schools" use Super Science materials to strengthen instruction in mathematics, social science, and English language as well as in science. Reactions of teachers to the project are being used in planning future issues of these magazines.

6. The Applications of Advanced Technologies program is responsible for supporting research, development, and demonstration in the use of state-of-the art computer and telecommunications technologies in education. The Program seeks projects that will lay the research and conceptual foundation for technologies that will be available in five to ten years.

"Intelligent Tutors in Algebra and Geometry" is a project at Carnegie-Mellon University. It started from a technology for producing tutors that yielded a one standard deviation improvement on high school mathematics achievement. The goal of the current research is to develop and demonstrate intelligent tutoring techniques that will yield a dramatic increase in the effectiveness of intelligent tutoring -- to a three standard deviation effect. The project is half over and achieving its objectives on schedule. Much of the second half of the project is to be devoted to demonstration and dissemination of the results achieved.

7. The Research in Teaching and Learning program supports expansion of basic knowledge about the processes of teaching and learning mathematics, technology, and the sciences, and about the factors that affect success in these fields. "Expansion" of knowledge includes its dissemination as well as its creation.

A project at the University of Chicago, "Survey of Applied Soviet Research in School Mathematics Education," is publishing adaptations of selected Soviet research monographs on the principles of conceptualization, problem solving, logical reasoning, programmed instruction, mathematical abilities, and spatial perception, and related articles interpreting the implications of the research for classroom instruction in the United States. The former activity enriches U. S. research in mathematics education; the latter activity accelerates the application of useful results of research to teaching in the schools.

8. The Informal Science Education Program utilizes broadcasting, museums, science clubs and other community-centered activities to assure a balanced and rich environment that encourages informal learning across a broad range. All aspects of the ISE program are designed to stimulate and maintain self-confident interest in science, mathematics, and technology.

The "Reading Rainbow" project of Nebraskans for Public TV, in Lincoln, is an example of NSF support of science content in an effort addressing broadly an important aspect of education. Five programs in this series are being devoted to science topics and science books. Candidate books are evaluated by scientists, educators, librarians, teachers, parents, and children -- for interest, appropriateness, readability, and suitability for television treatment. The programs produced to date have had substantial effects on homes, schools, and libraries. For example, booksellers report dramatic increases is sales of reviewed books; and librarians greatly increased requests for and use of these materials. **The FY 1990 budget for the support of the aforementioned four instructional materials development and research program is $48 million.**

9. The Studies and Analyses Program, **budget at the level of $4.4 million for FY 1990,** supports the collection and analysis of data on science and engineering education issues, and support of related policy studies and policy development. Assessment Studies assist the Foundation in a continuing effort to improve its own education activities, and to provide information for planning to colleges, universities, and governments at all levels.

A project of Horizon Research, Inc. (Chapel Hill, NC), "National Surveys of Science and Mathematics Teachers," is devoted to a related pair of national surveys. One is exploring through interviews of former teachers the factors (e.g., salary, working conditions) that influenced them to leave the profession, contrasting their attitudes toward teaching and their current occupations. The other is working through the National Assessment of Educational Progress to collect data from eighth grade science teachers on the relationships between teacher and classroom characteristics and student performance. The structure of the project assures comparability with NAEP data being collected on mathematics instruction.

10. The Young Scholars Program for talented secondary school students, **which with a current budget of $7.0 million annually supports nearly 5,000 students, focuses directly on students (especially members of underrepresented groups),** stimulating their interest in mathematics, science, and engineering, and helping them maintain options.

"A Rural Model for Connecting Young Scholars" is a project at Montana State University bringing high ability and high potential 8th and 9th grade students to the University for science-related career exploration activities. The project begins with a residential summer workshop of laboratory and field experiences; continues through a structured computer-

network set of activities designed to connect students in their local setting with each other and with University personnel; and concludes the following year with activities that expose the students to established science programs for high achieving students in the state.

11. The Career Access Program is designed to increase opportunities in science and technology for women, minorities, and the disabled. The activities supported by the Program are Comprehensive Regional Centers for Minorities and Prototype and Model Projects, **for which the FY 1990 budget is $11.9 millon.**

The Comprehensive Regional Center for Minorities at the University of Texas at El Paso involves in addition: El Paso Community College; the El Paso, Socorro, and Ysleta Independent School Districts; New Mexico Institute of Mining and Technology; Sul Ross State University; Western New Mexico University; and the Texas Region XIX Education Service Center. The predominantly Hispanic minority enrollment in the colleges and universities is at least 21,000, and in the targeted school systems at least 101,000. Center emphases include: focus on critical junctures in the science career pipeline; needs and characteristics of Hispanic students; involvement of industry, business, and community leaders. Center activities for students include: summer science day camps at elementary schools; summer math/science computer camps for 8th and 9th grade students; junior and senior high school level summer institutes in science and engineering; campus visit days; summer bridge programs for community college graduates. Center activities for teachers include: summer disciplinary workshops; a science/math aides program; regional conferences for school and college educators; and career workshops for counselors.

To expand our efforts beyond those represented by the eleven programs cited above, we have decided to make provisions for **mathematics and science teacher enhancement through the projects funded under the NSF Research and Related Activities account. Thus, for the Summer of 1990**, a specific encouragement will be directed at NSF-supported research facilities to promote a substantial expansion of existing and start-up planned teacher-serving programs. Among such facilities are:

- o the established Science and Technology Centers, Materials Research Laboratories, Engineering Research Centers, and Supercomputing Centers;
- o individual specialized facilities such as the National Center for Atmospheric Research; Research Center for Energetic Materials; and the several units of the National Optical Astronomy Observatories; and

- the numerous research laboratories in colleges and universities with NSF research grants.

The numerous centers supported by the Foundation are scattered across the nation, with a distribution approximating that of the general population, and deal with numerous disciplines. The laboratories having research projects supported by NSF are very widely distributed and are active in all of the NSF disciplinary areas -- mathematical and physical sciences, computer and information sciences, geosciences, biological and behavioral sciences, and every branch of engineering.

II. UNDERGRADUATE MATHEMATICS, SCIENCE AND ENGINEERING EDUCATION

The undergraduate programs constitute the Foundation's initial instruction-related activities at that important educational level, **for which FY 1990 budget is approximately $134 million.**

1. The Foundation-wide undergraduate instructional Instrumentation and Laboratory Improvement Program is designed to develop and implement new approaches to improve the effectiveness and efficiency of laboratory instruction, especially through use of modern instrumentation.

> Despite the growing important of importance of lasers and modern optics, undergraduate institutions rarely provide coursework in these increasingly pivotal areas. Lawrence University is undertaking a pilot program designed to determine the staffing and hardware requirements for meaningful instruction in lasers and modern optics in undergraduate institutions. It is developing courses at several levels, devising suitable laboratory experiments, testing various types of lasers and optical hardware, and developing instructional materials. Publications, visits, workshops, and outreach programs serve to inform other institutions of the details of the findings. Even before its completion, aspects of this program are being emulated at other colleges and universities.

2. The Faculty Enhancement Program supports efforts to improve the disciplinary capabilities and teaching skills of faculty members who are primarily involved in undergraduate teaching.

Grants are made to conduct regional or national seminars, short courses, workshops, or similar activities for groups of faculty members.

> The Departments of Paleontology and Biology of the University of California, Berkeley, offered a short course on Dinosaurs in conjunction with the 1989 Annual Meeting of the Geological Society of America. Fifteen experts on

various aspects of the Age of Dinosaurs are presented a cohesive summary of new research in the evolution, origin, phylogeny, adaptations, environments, and extinctions of dinosaurs and some of the plants and animals with which they lived. Special emphasis was being given to how to set up and teach a course on dinosaurs to undergraduate students. Courses on dinosaurs have already proven to be great motivating tools that stimulate students to learn more about earth and life sciences. Dinosaurs can also be used as a vehicle to communicate ideas on subjects as diverse as molecular biology and geophysics.

3. The Courses and Curricula Program provides support for efforts that will yield new undergraduate courses and curricula, with emphases on: involvement of research-oriented faculty; timely applications of new knowledge and technologies; re-thinking professional and pre-professional curricula; courses for nonscientists; and articulation with high school science and mathematics.

A project involving a collaboration between Duke University and the North Carolina School of Science and Mathematics is creating a new curriculum in which the calculus is taught as a laboratory course. It features an integrated computer laboratory for exploration and development of intuition, and emphasizes writing to promote student comprehension and expression. The graphical and numerical experiments place the spotlight on the student and learning rather than on the professor and lecturing. Students are responding to these activities with greater interest and are exhibiting better performance than students taught in conventional calculus courses.

4. Other undergraduate programs include Research in Undergraduate Institutions, Research Experience for Undergraduates, and Research Careers for Minority Scholars, each of which seeks to enhance the research capabilities and/or experiences of students or mathematics, science and engineering faculty members.

III. GRADUATE LEVEL AND BEYOND

The Foundation's research career development activities are the Graduate Fellowship Program and the Minority Graduate Fellowship Program. Through this prestigious pair of programs, a core group of outstanding graduate students is identified and provided extended support for advanced education.

Sylvia Lynne Sanders was awarded an NSF Minority Graduate Fellowship and elected to pursue doctoral studies in biochemistry at the University of California-Berkeley. Ms.

> Sander's father is a biochemist and her mother a teacher of mathematics; as late as high school, she had planned on becoming a physician. At the University of Kansas, her longstanding interests in mathematics and science led to her selecting chemical engineering as an undergraduate major. But when, as a junior, she took formal coursework in biochemistry, that field began to dominate her interests. Her thesis research is on secretory processes in yeast, with emphasis on the mechanisms for protein transport. Ms. Sanders hopes to pursue an academic career after receiving her Ph.D. -- becoming, as a professor-researcher, a role model for the next generation of black Americans.

The postdoctoral component of NSF's educational activities is the NATO Postdoctoral Fellowships in Science Program, through which outstanding recent recipients are enabled to study at over-seas research sites.

> Catherine Ann Briasco took a double baccalaureate in Chemical Engineering and Chemistry at Massachusetts Institute of Technology; she applied for a NATO Fellowship while still a graduate student in Chemical Engineering at Stanford University. The award of a Fellowship made it possible for her to spend a year at the Laboratoire de Technologie Enzymatique, Universite de Technologie de Compiegne, France. There she investigated spatial distributions of recombinant cell growth, plasmid stability, and oxygen concentration in immobilized-cell gel research career in private industry; at present she is working on protein-based pharmaceuticals.

The Presidential Young Investigators Program is the young faculty component of NSF's education and research support activities. Through it outstanding young scientists, mathematicians, and engineers are help to initiate and maintain the research activities that are expected of those in tenure-track faculty positions.

> Anthony R. Ingraffea earned a B.S. in Aerospace Engineering from the University of Notre Dame, but switched to Civil Engineering for his master's (Polytechnic Institute of New York) and Ph.D. Degrees (University of Colorado at Boulder). At the time of his application to be a Presidential Young Investigator (PYI), Dr. Ingraffea was Associate Professor and Manager of Experimental Research in the School of Civil and Environmental Engineering at Cornell University. During his tenure as a PYI, he did creative work in computer graphics -- integrating research and teaching functions. NSF's support of Dr. Ingraffea's PYI activities was matched by funding from three major industrial companies.

IV. PROPOSED OR RECENTLY INITIATED PROGRAMS

1. Statewide Systemic Initiative

Base on our experiences with other programs, it decided that NSF needed to become more visible at the State and local levels with innovative efforts to create parternships with States, localities, academia, and the private sector to bring about a fundamental reform in mathematics and science education. With our FY 1991 budget, NSF will actively encourage proposals that seek to put in place broad based fundamental changes at the State and local levels that will complement ongoing efforts. We believe these efforts can substantially improve elementary an secondary science and mathematics educations over the long terms.

This is the rationale for our Statewide Systemic Initiative recently announced in conjunction with the National Govenor's Association. With this effort, NSF will take the next leadership step by working with the States to plan, design, and take action that only the States can take to bring about major educational change. They will, quite appropriately, build on the education improvement efforts that are beginning to yield positive results in many of the NSF supported teacher training and curriculum development projects. More importantly, the States Initiative has as its purpose "to make happen" the systemic, comprehensive changes necessary for major improvements of the teaching and learning of science and mathematics at all educational levels. The program involves teachers, the business community, the State and local education entities, and, in particular, the Eisenhower Program of the Department of Education.

2. Alliance for Minority Participation Program

This strategy to effect fundamental change in education and human resources is also evidenced by our FY 1991 proposal to initiate the Alliance for Minority Participation Program. This program grew out of our realization that, despite the many efforts to improve participation of minorities in the Nation's science and technology enterprise, minorities remain severely under-represented in science and engineering. Obviously, a more strategic approach is needed to attract a significantly increased number of minorities into science and engineering. Substantial process is essential; the demographics clearly show that a significantly increased portion of the S&E workforce will be represented by minority scientists and engineers.

However, attacking this problem successfully can not be done solely by NSF, higher education, industry or the private sector alone. Rather, there has to be a collaborative effort between all of these participants. This has lead to NSF's Alliances program to support efforts that concentrate on increasing the number of undergraduate and graduate S&E degrees received by minority students, by the formation of explicit partnerships between NSF and other sponsors (e.g., other Federal agencies, S&E industries, private foundations, higher education institutions).

These two programs are examples of NSF efforts to attack the science and mathematics education problem in a concerted and comprehensive fashion. We also have similar comprehensive efforts targeted at the undergraduate curricula for engineering, mathematics, physics, chemistry, computer science, biology, and the geosciences. All these efforts are structured on the premise that our programs must focus on each of the critical decision making points along the education spectrum if we are going to make a difference in the science, mathematics, and engineering education and training of today's and tomorrow's educated citizenry.

Remarks
Dr. Luther Williams
Assistant Director for
Education and Human Resources

Subcommittee on Science, Research,
and Technology

Thursday, June 7, 1990

Thank you. It is an honor to appear before this committee, and an honor to have been asked to serve as the NSF Assistant Director for Education and Human Resources. I look forward especially to a close association with this Committee as we seek the shared goal of supporting the NSF programs in education and human resources and further developing the Nation's human resources in the science and technology area.

Support for education and the development of human resources is one of the two major missions of NSF. Its relevance is increasing rapidly as the nation realizes its importance to international economic competitiveness.

My commitment as Assistant Director will be to improve the Foundation's programs in these areas in every way that I possibly can. And I want to make one point very clear: the changes announced last week will strengthen, not weaken, these programs.

In terms of organization, the four divisions and the office that now make up the Science and Engineering Education Directorate remain as units of the new Directorate. To these we have added the programs directed specifically towards recruiting and retaining in science and engineering, women, minorities, and persons with disabilities. This will allow closer coordination among programs with closely related goals: for we need both more students in science and mathematics programs, and higher achievement for those in these programs.

In addition, we will strengthen the coordination and oversight of other NSF education and human resources programs, especially at the undergraduate level.

About two-thirds of our undergraduate efforts will continue to be administered by the research directorates, because this is the best way to ensure that there is a close link between research and education. But these programs also need close coordination to ensure that NSF has a coherent educational effort covering all the disciplinary areas effectively. As Assistant Director, I will provide that coordination. In that I will simply be continuing my career interest in combining research and teaching -- something I have emphasized at every point in my academic service -- and I will be continuing to work with the research Assistant Directors as I have in the past. I believe my personal background in research will make this easier.

I will also work hard to achieve coordination among the various agencies working in science and engineering education. As Senior Science Adviser to the Director for the last year, I have worked hard with the Department of Education to achieve this coordination. Within the past two months Assistant Secretary of Education Christopher Cross and I have identified several important areas for cooperation in the near future:

- The NSF Statewide Systemic Initiatives program will cooperate with the ED Eisenhower Fund for mathematics and science education to ensure that the funds are used most effectively for math and science purposes;

- We will coordinate efforts in minority programs and in urban education;

- We will pool our efforts in assessment of educational outcomes to improve our ability to know how schools are doing;

- And we will complete an inventory of our programs to identify other areas for possible cooperation.

This degree of cooperation is unprecedented, but it is only the base from which we will move forward.

With respect to OSTP, I serve with Under Secretary of Education Ted Sanders as Vice-Chair of the FCCSET Committee on Education and Human Resources, and I chair the working group concerned with developing an integrated FY 1992 federal program. In this and in other ways I will continue to work with Dr. Bromley and other key Administration officials to make sure that NSF takes a strong leadership position federal efforts in education and human resources.

Finally, I am concerned with the need to increase the visibility of education and human resources activities at NSF and across the government. The President took the initiative in setting the goal of being first in mathematics and science education by the end of the century. It is up to us to develop the strategy to meet the President's challenge. One piece of that strategy must certainly be increased attention to human resources issues by every player: the various federal agencies, the states, private industry, the schools, teachers, parents, and students. As Assistant Director, I view my task as one of stimulating and leading that effort in every way that I can.

Mr. VALENTINE. Thank you, sir.

Mr. Bloch, let me ask you first of all this question. I understood you to say that in your opinion what is sought, the aim, the goal of the proposed legislation, is all achievable without the legislation. Do you think that the goals will be achieved without the legislation?

Mr. BLOCH. Mr. Chairman, the reason I made that comment before is essentially that if you look at some areas of the bill, such as instructional science museum assistance, advanced technician training in centers of excellence primarily focused on two year schools, college/university partnerships, undergraduate faculty awards, and doubling graduate fellowship programs, many of the programs and activities that we have in the Foundation are essentially geared toward many of these areas that you are discussing here.

I think that the question one can always raise and must always raise is: are we doing enough? I will tell you quite frankly, no, we are not doing enough. We are not doing enough in many areas for which we have responsibility, but we are trying to exploit the best we can the resources that we have. We are trying to stretch those resources by essentially putting in place coalitions so that the Federal Government funding is not the only funding that goes into this area.

So I would say that we have a broad outline of many of the things that you are trying to achieve here. One can argue, obviously, as one can always argue, about the level of the funding that we have available.

Mr. VALENTINE. Were the organizational changes which you talked about and which I am sure will be discussed further discussed in advance with the National Science Board, and is the Board in agreement with the decision?

Mr. BLOCH. Absolutely. I discussed it with the National Science Board, with the total board. I had discussions before that with the Executive Committee of the National Science Board and the Education and Human Resources Committee of the National Science Board, so it was covered really about three times in different settings.

Mr. VALENTINE. Will the reorganization effort involve any significant changes in the emphasis of the science education programs, either in terms of broad allocations of resources for precollege, undergraduate, or graduate level activities, or in the kinds of programs which are emphasized?

Mr. BLOCH. No, not at all. With the programs that are in place today, in the current budget year, the funding that we are asking for in our 1991 budget, which Congress is in the middle of discussing, we have no intention of reallocating or changing or anything like that in those specific areas.

Mr. VALENTINE. Back to the National Science Board. When this consultation occurred, were these meetings open meetings?

Mr. BLOCH. No, they were not. It was a closed meeting of the Board because I had to discuss in great detail personal kinds of problems which I think would have been completely inappropriate to discuss in an open meeting.

Mr. VALENTINE. What do you see, Mr. Bloch, as NSF's role, if any, in reemphasizing the importance of undergraduate teaching at research universities? This is sort of an addendum or follow up on Mr. Brown's question.

Mr. BLOCH. As I said at the end of my statement, I certainly align myself with Mr. Brown's comments to a great extent. It has been the focus of the discussion internally in the Foundation and with the National Science Board.

Let me point out what we have been trying to accomplish. First of all, the undergraduate programs that we have put in place coming from the Foundation, being solicited by the Foundation, I think send a message to the university community, and especially to the research community, that here is a neglected area. Secondly, I have seen, and Mr. Brown has mentioned, during the last few months, a reawakening in research universities of the need to focus more on education, especially undergraduate education.

The AAU, for instance, is focusing on that. We have offered our help in terms of letting them know what our programs are and how they could link into them. I think the statement by President Kennedy of Stanford is a statement of that concern that he personally has for his institution, so I can see quite a few elements.

We have sent out an importance notice, one of seven, which asks essentially that researchers that come in for grants tell us what the effect of that grant would be, if they should get it, on education, especially undergraduate education. I should tell you quite frankly, that that important notice is under strong criticism both from some parts of the research community and also from within the Administration. It has to deal with paperwork and things of this sort. I think that we can come to an agreement on that, but that was our way of pointing the finger at a very important kind of activity.

I should also tell you that over the last two years or thereabouts, we had a number of workshops that focused on undergraduate education. The workshop members were coming not only from four year colleges, but from the research universities, again, as a way of pointing the finger and also finding out more of what we need to know for our own programs.

I think we are doing a lot. Can we solve the problem by ourselves? No. I think that Mr. Brown is absolutely right. There has to be a cultural change in the university itself, and much of that has to be brought about by the university.

We can focus on it; we can push; we can talk about it. I talk about it in many of my speeches. I give Mr. Brown's speech. He does it better than I, but so be it.

Mr. VALENTINE. Maybe he gives yours sometimes, too.

Mr. BLOCH. Maybe.

Mr. VALENTINE. I have other questions, but I want to recognize the splendid turnout of my colleagues on this subcommittee by saving some of my questions until the end of the session and by yielding to them.

I will recognize Congresswoman Schneider at this time. After that, since he was not here for an opening statement, we will yield to our distinguished colleague and former chairman of this subcommittee, Mr. Walgren.

Ms. **Schneider**. Mr. Bloch, given the fact that the Federal Government is primarily responsible for creating the research ethic in the universities, the research culture because of their Federal grants, how do you see us shifting into creating more of an educational or professional approach?

Mr. **Bloch**. I think that you are right in saying that the Federal Government, by its actions, not in a direct way but in an indirect way, is really determining the ethics in universities, and the pendulum has swung too far in that direction. At one time it was education and research which was the mission especially of the research universities. Today, many times, it is research and research. So we have to swing that pendulum back.

What I said before, I think, applies as an answer to your question, also. You can do that by examples, by coming out with initiatives that focus on undergraduate education. You can do it like what we have been doing over the last three or four summers, by establishing a program that essentially focuses on undergraduate students and brings them into the research laboratory either during the school year or during vacation time.

I think that by doing that, we are telling the researchers something—these are supplements to a great extent, although not exclusively, to our existing research grants. By doing that, we are essentially telling the researcher, "Look, you have another obligation. It is called education, and by the way, there is an undergraduate student who needs your help and your support."

That program has been highly successful. We have increased it for three years in a row. It is about $17 million that we are spending on it, and it touches a lot of undergraduate students. What it does for the students is one thing, but I think that what it does for the researcher is something else, namely saying, "Look, here is a job that you should also be doing."

Ms. **Schneider**. What do you feel NSF's role could be in helping to have a more effective use of new technologies in some of the precollege classrooms?

Mr. **Bloch**. We have a program that is looking at instructional technologies. I think that what we can do is what we are always doing in a generic kind of sense, namely, look for ideas that people have, make sure that people have the necessary wherewithal to implement them, and then try them out in the various settings.

We have been focusing for many years, by the way, for probably 10 to 15 years, on computers in the precollege classroom. We funded the BASIC language 15 to 20 years ago, or whenever it was. So it reaches back in time. There are newer technologies around today that deserve that same kind of treatment, and we are trying to do that.

Ms. **Schneider**. What might some of those technologies be?

Mr. **Bloch**. You could think essentially of video disks as one example. It is a combination of video disks and computers.

More important than that, I want to focus you on software. You know, we are always talking about hardware because you can touch it and see it and feel it and it's there. But the software aspect is, I think, more important. We are focusing on that, not in the precollege area but in the undergraduate area. We have a few programs in mathematics, calculus in particular, that focus on developing new software that could be used in the classroom or laboratory kinds of settings to explain examples, principles, and exercises and so forth.

I think that there is a lot that we can do. Sometimes, it is highly visible and sometimes it is not, as in the case of software, which is equally or even more important.

Ms. SCHNEIDER. Beyond the NSF development of it, is there the ability, for example, to have a cooperative arrangement with the Department of Education that would enable more schools to buy this software?

Mr. BLOCH. I mentioned in my opening statement that, over the last few months specifically, we have had many discussions with the Department of Education as to how we can get closer together and do things closer together. One area that we have been using in the past and that we probably should use much more extensively is a distribution network that the Department of Education has, that we do not have, which reaches out to every school or certainly into every school district.

With that network we can distribute some of the developments that we have been funding that have proven out. I think we have to bring that to a much higher level than is being done today.

Ms. SCHNEIDER. Sounds good.

Did you want to add something, Dr. Williams?

Dr. WILLIAMS. Yes. For the past several months, I have been the senior science advisor to Mr. Bloch and have served as a coordinator between NSF and the Department of Education in coordinating our respective programs. We identified quite early the whole issue of dissemination, with NSF having more extensive use of its National Diffusion Network.

We quite appropriately started by conceding that at least in the recent past, it has not worked well. We worked out different strategies for use of it, and we have developed a plan, in my view, that has real deadlines and real deliverables. And I am very encouraged.

Ms. SCHNEIDER. Sounds good. Thank you both very much, and thank you, Mr. Chairman.

Mr. VALENTINE. Thank you.

Mr. Walgren?

Mr. WALGREN. Thank you, Mr. Chairman.

I really think that we have got some deep problems in this area although we come to these Congressional hearings and it sounds good. It has sounded good for the last 10 years, and we have not made an awful lot of progress in science and engineering education at NSF in any event.

If someone wanted to challenge that statement, then the least that could be said without challenge is that the Congress has been out ahead of the Administration every year in terms of the effort that we believed should be committed to science and engineering education. I confess that I view these changes at the time they are coming—and I focus mostly on the time and the way in which they were made—as a great step backward for NSF.

Mr. Bloch, I understand that you are planning on leaving the Foundation sometime in the very near future. In many ways, your tenure has seen very good things, much of it the result of leadership that you have given the agency.

At the same time, I think we will look back on this as a last dismal chapter in the events surrounding science education efforts by the National Science Foundation. What I really do not understand is why there would be such a change made from what all admit has been a very positive experience, at least with respect to the director and the energy with which that director was received by the country in the last several weeks of your directorship.

I guess I would like to ask how you weighed making that change when you would have to take into the balance that whoever is the new director of the Foundation coming in the very near future would not have any ability to make his or her own choice in an area that is fundamental—probably the greatest challenge that we face as a nation—would not have the ability to write on a clean slate at that point, but would certainly and properly be directed in the area where Dr. Williams would lead. I have no reservation about the area Dr. Williams would lead, but I do feel that a new director of the National Science Foundation should have—and perhaps they will, but we know that a new person is not turned away from and very well should not be—but why was that new director not given the opportunity to select their own person for the most important function of the National Science Foundation?

Mr. BLOCH. Mr. Walgren, you asked a number of questions that I really need to address. Let me get to your last one first.

There is continuity in the National Science Foundation. The National Science Board is a continuing body. The deputy director of the National Science Foundation, who was just appointed six months ago by the President, is a continuity. The director is only one position among the three that I mentioned that is leaving, that is changing.

Before you came in, I answered the question of the Chairman: was the National Science Board involved in this decision? And my answer was, yes, in more than one form. The total National Science Board and two of its major committees were involved.

There is never a good time to make a change. Changes have to be made from time to time, however. It was my conclusion that this was the time to do it rather than wait six months or twelve months before the next director is in place. I do not know how long it will take. I have no idea.

My term is up on August 31st. That is the only firm date in this whole episode. I do not know when the next director is going to come in.

If you look at the history over the last few years in making appointments rapidly of this nature—they have not been made rapidly. You have seen this yourself. So I don't know when the next director is coming in.

Time is of the essence. It was very important that we position ourselves, not for tomorrow, not for next month, not for this year, but for the future. A new director, together with the National Science Board, can overrule that or make other changes. But the point I want to make is that there is some continuity there.

The National Science Board is a continuity. The deputy director is a continuity. I did not do it in isolation and without consideration for a new individual coming in the door. In the last analysis, it has to be a management decision that is being made. That is the only way you can administer a complex organization like the National Science Foundation.

I hope I have explained—probably you will not agree—but I hope I have explained the process I went through and what the decision elements were and who participated and who is still around long after I am gone.

Your first point, that we have not made any progress in 10 years—I really need to dispute that. I came to the Foundation, and so did Dr. Shakhashiri, at a time when there was no education program in the Foundation except the Graduate Fellowship Program.

Today, there are programs in place in precollege areas. There are a large number of programs in place in the undergraduate area, and we have strengthened significantly the human resources effort, especially for underrepresented groups. So I cannot agree with you that no progress has been made.

Mr. WALGREN. I certainly would give you that this area has been substantially resurrected over this period of time.

Mr. BLOCH. We started from nothing, from zero.

Mr. WALGREN. That is correct. My point is that it has been very little thanks to the Administration that these kinds of dollars have been put into place. There has never been the Administration asking for more funds than were proposed by the Congress in any of these years to my knowledge.

I guess that my real frustration is that, although we can point to progress over these years, this is a critical problem for the Nation and our level of effort is vastly lower in the National Science Foundation than it has been in previous periods. My greatest dismay is that, by making the personnel change in the way it was made and at the time it was made, there is a very clear message sent that any individual who publicly states the facts in science education in a way that compares our present effort with what we have traditionally conducted, runs real risk of losing their job.

In making this personnel change as you have made it, you have chilled the ability of other administrators to be candid about the circumstances which we find ourselves in. To my knowledge, Dr. Shakhashiri was the only one who really had the courage to put a number on the level of effort that we need to both adequately cover a field and also point to a number that described the level of effort that was made in the past.

We all talk about the goals and the words all sound good, but ultimately, it is discreet levels of effort that count. At present, as you know, we are less then one-half the effort in science education at the Foundation in that directorate that we were at in 1967.

I do not know how anybody viewing the importance of science and engineering education for the future of the country can be satisfied with that level of effort. It is woefully inadequate. What has happened here is that the individual who pointed out that the words were cloaking something woefully inadequate is essentially removed from the circumstances at a time when that can be the only message that is sent because of your departure and the fact that the normal course of affairs would be to let an incoming director have their choice for who would conduct this central function.

Mr. BLOCH. Again, I need to take exception to your statement. I probably am the one who over the last six years has pointed out the inadequate funding of the National Science Foundation in total. I am the one who has tried to focus the Administration and the Congress on the doubling of the National Science Foundation's budget, including the education and human resources area.

In fact, that area, thanks to Congress to a great extent—no doubt about it—has grown faster than the rest of the Foundation. I think that I have pointed out over and over again, and I do not know how many hundreds of times, that what the Foundation is asked to do and what its capabilities are are not synchronized; that there is a gap between the two. I take some credit for that.

Secondly, let me say one other thing. Every assistant director will point to a number that he needs for his particular area. The engineering directorate is doing it time and time again. The computer science directorate, the physics and mathematics directorate, on and on. Every AD has that right and that particular duty.

That had nothing to do with the organization changes. The organization changes were to put us into a proper position. I cannot agree that this sends a chilling signal, as you put it, to all of the assistant directors. I do not think they interpret it that way.

Mr. WALGREN. Mr. Chairman, I appreciate the time you have given me. I would like to ask unanimous consent to enter a statement into the record at the opening part of the hearing and also introduce to the record a copy of a letter signed by you, Mr. Chairman, Mr. Brown, and myself, to Mr. Bloch in advance of these steps being taken.

I believe that the Foundation will pay a great price for these steps because of the way they were taken. To me, it represents in a sense the folly of the multi-year authorization path with which we are moving. I believe that, had we been on single year authorizations, we would have had the kind of advance consultation and, perhaps, the effect of these steps would have been then given greater weight than they were.

I also believe, Mr. Chairman, that we have got to go back into this area of science education as a committee tooth and nail. I would ask your help and your leadership in that.

It certainly seems to me that the time is right, when we are at less than half the effort in science education with the Science Foundation than we were in 1967, that we look in detail at what has happened since 1980; that we look at the programs that the Science Foundation has put in place during those years, their relative funding levels, and the direction that they were taking and the direction that Dr. Williams, or whoever is in that position, can give us.

I would urge us to hold hearings specifically on that subject, and I look forward to working with you in that process. Thank you, Mr. Chairman.

[The letter mentioned above follows:]

Congress of the United States
House of Representatives
Washington, DC 20515

May 31, 1990

Mr. Erich Bloch, Director
National Science Foundation
1800 G Street NW
Washington, DC 20550

Dear Mr. Bloch:

We are deeply concerned about information that the Foundation is considering restructuring the Science and Engineering Education (SEE) directorate.

Science education and the SEE directorate represent an area of extreme political sensitivity. In view of the recent history of Administration budgets for NSF's education function, we feel very strongly that any substantial change in this program should be developed only with prior, close consultation with the committees of the Congress that have been directly involved in reestablishing this program at the Foundation. Any proposed reorganization in this area should not be implemented without taking into account Congressional input.

As Members who have been strong advocates of Congressional support for important changes you have recommended for the Foundation, such as multi-year funding authorizations and the commitment of substantial resources to Science and Technology Centers, and as Members who feel a very special responsibility for the science education function at NSF, we would be surprised and violated if changes were made in the direction of the SEE directorate without our prior knowledge.

As you know from your personal relationships with each of us, we want to support the Foundation's best interests from our various positions in the House of Representatives and trust in your cooperation with us in that endeavor. In view of the upcoming hearing on science education before the Subcommittee on Science, Research and Technology scheduled for June 7, we ask that no steps be taken with respect to any proposal for the reorganization of the SEE directorate before that hearing.

We look forward to talking with you about the future of science education at the Foundation.

Sincerely,

Doug
DOUG WALGREN
Member of Congress

George
GEORGE E. BROWN, JR.
Member of Congress

Tim Valentine
TIM VALENTINE
Member of Congress

Mr. **Valentine**. Thank you very much.

Mrs. Morella?

Mrs. **Morella**. Thank you very much, Mr. Chairman.

On a different subject, Dr. Bloch, I wanted to comment and ask you about why OMB and OSTP and the universities, from what I understand, are opposing that NSF Important Notice No. 107. Do they give reasons? It seems to make some sense that you would look at the impact.

Mr. **Bloch**. I think that we probably made a mistake putting that notice out the way we did because inherently what is implied by asking that question is essentially a filling out of a new form or the making of a survey. This is something that we should have cleared through a notification in the Federal Register first. We have been in a technical default position, so to speak.

Mrs. **Morella**. In other words, the concept is a good one?

Mr. **Bloch**. May I finish?

Mrs. **Morella**. Yes.

Mr. **Bloch**. That was one thing that we ran into. The second one—and we heard from a number of people in the community. I would say that we heard some supportive evidence also that this sends a message to the research community that unless your project or program can be directly associated with an effect on education, especially undergraduate education because we mentioned that in there, that that proposal will not fare well in the evaluation process.

The third thing is that I think there are some people who are saying that it sends a message that says unless your program is geared more toward the educational arena, and less toward the research area, again, you will not fare well. As I understand it, and as I interpret it, these are the three messages or the three problems that we are encountering.

Mrs. **Morella**. In other words, the semantics of asking such a question is such that it seems to create a little paranoia that research has got to be measured by specificity or specifics. On the other hand, how do you feel personally? Do you not think there is some validity in something like that?

Mr. **Bloch**. I think you said the right word. It is a paranoia, certainly. It is probably made even more so because of the fact that over the last few years the number of grants that we are making compared to the total grant requests that we are getting has been decreasing.

At one time it was 43 percent of the requests. Today, we are only honoring about 30 percent. This in itself puts a squeeze on people. In that kind of an environment, paranoia is easily understood.

Mrs. **Morella**. What can you do about it? Is any progress being made?

Mr. **Bloch**. We are looking at that, trying to get out of this particular thing. We want to make sure that people understand that the balance between research and education is very important. We do not want to give up on the principle that we wanted to get across, and we have to find a way of relieving some of the paranoia and also getting us out of a technical deficiency.

Mrs. **Morella**. I would think that would be very important in this period of sending messages—we talk about sending messages in so many ways. Isn't that sort of a bad message in a way when you think about the fact that there is a problem with saying that there is a relationship between education and research?

Mr. Bloch. Sure, and that was the reason we put the important notice out in the first place.

Mrs. Morella. In a way, that really ties in with another concern that I have. That has to do with the whole concept of undergraduate teaching.

I think you mentioned in your opening comments about the fact that this piece of legislation really is what you already can do. I think that one of the areas that you do not have the authority for at this point, as I understand it, is the undergraduate teaching awards. I want to ask you what you think about that, the importance of something like that, and tie that in with: do you have a concern that more universities and colleges seem to be shifting their emphasis from teaching to research?

Mr. Bloch. I think you are right. The awards are probably a new entry there. By the way, we have awards in the precollege area—mathematics and science teacher awards in the precollege area for both high schools and middle schools. We only exercised the high school one until this year, and this year, we are doing it for both.

That is one thing, again, sending a signal. I am not so sure that in this particular area of undergraduate education, that is as important as some of the other programs that we are undertaking, like instrumentation for undergraduate laboratories, like teacher preparation, like curriculum development. I would put that on a higher level.

Awards, recognition, is important—no doubt about it. I am not so sure it should have the first priority.

Mrs. Morella. Yes. I just think that one of the things that is critically important to us is the fact that it is through the teaching that you are going to motivate more people. As we talk about Work Force 2000 and the sparsity and competitiveness, I just think that we cannot lose sight of that as being one of goals.

Thank you, and thank you, Mr. Chairman.

Mr. Valentine. Thank you.

Mr. Brown?

Mr. Brown. Thank you, Mr. Chairman.

Mr. Bloch, just to deal quickly with the reorganization—those of us who signed the letter to you were very much concerned that we might have a phenomenon taking place here which we have encountered in other parts of the Executive Branch in which a person like Dr. Shakhashiri, who was doing what we thought was a very good and highly visible job, was removed from that position because of his effectiveness, not because of ineffectiveness, and the fact that he might be getting a little ahead of the Administration. That is disturbing. That happened over at DARPA with a very effective administrator who apparently got a little ahead of Administration policy. It has happened in other areas.

Obviously, it will concern those of us in Congress. Now, that is, of course, only one of many reasons why a person can be shifted or an organizational change made. I will tell you that it is inappropriate for the Congress to be looking over your shoulder at every change that you want to make over there. You could not function with that, and it is just improper.

However, we should be concerned when we see as a matter of practice that the Administration is making changes because of the effectiveness of a particular individual in a program. I am struck by Dr. Williams' statement that he is concerned with the need to increase the visibility of education and human resource activities at NSF and across the government. We thought that is what Dr. Shakhashiri was doing over there.

Having said that, I do not know that we can solve the problem at this point, but I do want to indicate to you that this is our concern. I would like to have you make some statement to me indicating that you do not feel that the changes made there were because Dr. Shakhashiri was doing what Congress wanted and doing it effectively. We would not like to see that happen.

Mr. BLOCH. Mr. Brown, let me assure you that, first of all, that move has no relationship whatsoever to the one that you mentioned before that took place in DOD. That was a decision that was made by me and the National Science Board and not by the Administration. I want to make that very, very clear. That is point number one.

Point number two is: I acknowledged in the National Science Foundation when I had a meeting with the staff and I acknowledged here in my opening statement the responsibility and the effectiveness of Dr. Shakhashiri over the last six years that he has been acting in that particular capacity. I do not consider that he was ahead of the National Science Foundation in what he was trying to achieve. We all want to achieve exactly that.

I have more boundary conditions on me than he has on himself. I think that is how it should be. So many times when an assistant director comes in, I accept what he does but sometimes I can not accept it because I do not have the wherewithal to deal with it. There can be some differences in that particular way.

The main reason for making this change at this particular point in time is what I indicated before. We need to reconstitute ourselves in a way that we will be linking closer together than we have in the past in the education and human resources programs. That is what I wanted to accomplish. Doing that one, I then asked myself the question: who is the best person to head up this new combined kind of effort? As always in difficult decisions, one individual comes out ahead and the other one does not. I have lived through that myself.

Mr. BROWN. Certainly, I think you have made a coherent and logical case for the action you have taken. We suspicious Members of Congress are always trying to look beyond the obvious and see what may lie beneath it. However, I am not going to belabor that point. I think you understand our situation.

What I do want to belabor a little bit is your statement about the role of Congress. In effect, you are telling what the Japanese are telling us. "Don't criticize us; correct your own mistakes first." You are telling that to the Congress, and I agree with many of your criticisms of the Congress. But what is our role to be and how are we going to achieve this interaction that you prize, which we might construe as just, "You give us all the money you can, and we'll do the best job we can, and don't bother us with anything else?"

Mr. BLOCH. No, not at all, Mr. Brown. I do not think that that is my attitude.

I appreciate Congress' role. I appreciate its input. I appreciate its criticism and review. All I am pleading for is essentially that you give us some maneuvering room and some leeway. Give us the capability of coming up and showing to you and proving to you a strategic plan and then see how our programs which we are establishing follow that particular strategic plan instead of telling us—$15 million here and $30 million here and $14 million here.

If you could agree on that particular base—you know—what is it that we are trying to achieve? Then I think it is very proper for Congress to also ask the question: how are you going to achieve it, and monitor how well or how poorly we are doing?

Part of what I have said in the past and what comes through in my statement here is the fact of the prescriptive nature of many of the programs. I think you are putting a great burden—I am not saying that is necessarily true throughout—but it is putting an unnecessary administrative burden on us and detracts from our efforts and effectiveness.

The second thing is that each program might be extremely important, but does it make sense in total? We have to move education forward and move the country forward. Are we doing it? Judge us by that and give us the ability to come forward with a strategic plan, show how our programs match with it, and if you see any holes in it, by all means, tell us where the holes are. We are trying to do our best.

Mr. Brown. Dr. Bloch, I am very supportive of the NSF. I think you know that. And I am very proud of what you have accomplished, but for the life of me, I can not understand why it is perfectly all right for you to take on a brilliant, innovative program like with young scholars and push it when you initiate it, or the President initiates it, but if the Congress comes up with exactly the same thing, you say we are interfering with you.

Mr. Bloch. No, not at all. First of all, if this program exists already, let's say, does it meet your criteria or does it only meet our criteria? We can change programs. We have changed programs. We like any kind of input we get from the community or the Congress or anybody else for that matter.

We have worked very closely with individuals on this committee many times in the past. I have never held back anything. And if you think that we are not doing a program that we should be doing, by all means, let us know that that is the case, and we certainly are going to take that very seriously.

Mr. Brown. I know you don't need legislation. I have heard this from every department head in the government. They say that the Constitution gives the President all the power he needs, and we just don't need legislation. I just don't buy that argument.

Now, you tell me specifically what is wrong with the idea of recognizing outstanding college level science teachers by giving them some recognition like we do for many other classes of people and which we do not do for science teachers at the present time. What is wrong with the idea, which is incorporated in this legislation and which I just happen to be the author of? [Laughter.]

Mr. Bloch. As I said before, I don't think there is anything wrong with that. My question that I have is: is that where we want to focus, to put the money in? Where is it in the priority of things? That is my question.

I think you can answer that very clearly if we have in front of us and if we agree on a plan, a strategic plan, that says here is a problem and here are some of the solutions. That might very well be one of the solutions.

Mr. **Brown**. Thank you, Mr. Chairman.

Mr. **Valentine**. Thank you, Mr. Brown.

Mr. Buechner?

Mr. **Buechner**. Mr. Bloch, I guess I am going to digress from some of the earlier remarks which seem to lapse back into the old argument about the Administration not doing this and that. I would just remind everyone that the Administration does not write the checks and does not do the appropriations. This Congress does.

This committee has had a tremendous commitment to NSF, but our colleagues on both sides of the aisle and in both bodies have not always felt the same way that we have. So I think it is unfair to say that somebody living down on Pennsylvania Avenue is the person who is the prime mover for any default or deficiency that exists in these programs.

We can disagree all we want about who ought to write what and do what. I would like to ask you some questions about why we are here today. You mentioned briefly computers.

Dr. Williams, I am really glad to hear that you are the person acting as the liaison with the Department of Education on this. Maybe you are the one that ought to answer this question.

I get the understanding in meeting with educators that although we point with pride to the numbers of computers that have been made available in school districts throughout the United States, I also get the impression that a lot of them are already antiques that can not use the type of software that Dr. Bloch mentioned. I would relate this to the same type of problem that we have in trade schools and shop classes where we are training people to do such things as type setting in a day in which type setting is actually a non-functional profession because computers do the work.

What can we do to actually have the right types of computers, the right types of software, in school districts? I would also like your comments about whether our teachers are prepared to use those computers?

Dr. **Williams**. I think you have correctly described the problem in the sense that there has been emphasis on computers per se. What I think needs to be done is the following. All of the comments I make today have to be put into the context of my having been in this position three days.

The issues seem to me to be the following. What one desires to do is to integrate a computer as one system for educational technologies in the context of an educational program. The emphasis is on the program, which would include making sure that you had the appropriate software and that there was a match between the software and the computer, vis-a-vis a specific educational exercise, science, math, or whatever one is teaching.

What I am attempting to say is that one needs a comprehensive approach in thinking about the use of computers in education, or use of technology in education, not being led to believe that it is necessarily because one has acquired or made provision for computers in the classroom per se. That is the way that one ensures that they are really state of the art.

It also seems to me that parallel to that comprehensive view, one would then have a very clear picture of the kinds of competency that would be required for the teachers to use them. The two should go in parallel.

Mr. **Buechner**. Would it be—either of you can answer this—would it be out of line to think that there is a possibility of coming up with a "McGuffey computer system?" I mean a fundamental computer system where, if we got all the computer manufacturers or retailers in the United States to come up with a basic computer system that could be put in school districts, understanding that the software would be upgradeable and changeable, that literally would provide a basic system, without our always being involved in having 35 different kinds of systems.

Mr. **Bloch**. I will be glad to talk about this subject. Mr. Buechner, that has been tried in the past. In the 1950s, I was involved in a program to design a computer for precollege education. It was a big flop. The computer world moves too fast for that, so I do not think so.

Second, the situation today is quite different. The compatibility issue is one that each manufacturer takes into consideration because each manufacturer wants to have his product as universally usable as possible. That is really on the shoulders of industry, so I do not think that is the right approach.

I sympathize with your comment about two things. First of all is teacher training in the use of computers. I think that is a prerequisite.

Mr. **Buechner**. Could I interrupt you a minute? Do we have through NSF any teacher training programs that we are funding to do just that?

Dr. **Williams**. Yes, we have some, especially under the Teacher Enhancement program.

Mr. **Bloch**. But I think it is more than just what NSF has. I am really focusing on teachers in general, no matter where they are. I think that that is the first prerequisite.

The upgrading of computer hardware is very important. We see that all the time in many other areas, such as instrumentation upgrading. Instrumentation becomes obsolete—no doubt about it.

We usually do not focus on the upgrading part. We usually do not lay out a kind of life cycle program for an investment like a computer, be it in a classroom or in a laboratory or anywhere else. I think that is where we are all making a mistake, including the National Science Foundation.

We have to be much more alert to that because we are on a three year cycle. It does not mean that every computer in the country has to be upgraded every three years—not at all. But I do think that there has to be a deliberate kind of a plan, not that after 10 years, you are still working on the same computer that at one time was capable of doing what you wanted to do but is no longer. I think this is a much more general problem.

Mr. **Buechner**. We have other questions and other panels. I want to thank both of you and, Dr. Williams, I certainly look forward to working with you. I think that you have quite a challenge on this committee.

Despite all of this sort of volcanic politics that you have seen erupt occasionally, we actually have good lava that comes out. So, thank you.

Mr. **Valentine**. Mr. Price?

Mr. **Price**. Mr. Bloch, in your testimony, you indicate that 2-year colleges are now eligible for support under all NSF programs focused on undergraduate science and engineering education. Of course, 2-year colleges benefit from such programs as curricular materials development for lower division undergraduate instruction regardless of where those materials are developed.

However, my strong impression is that at least in the past, NSF has been reluctant to assist 2-year colleges in improving their capabilities for technician training. I must say that Dr. Williams' statement, by virtue mainly of its omissions, is not particularly encouraging in this regard.

Now, the rationale in your testimony for not supporting the subcommittee's proposed legislation is that no additional legislative authority is needed to carry out the proposed science and engineering education programs. I would suggest that, while this may be true, one purpose of the legislation is to reinforce certain program emphases at NSF and also to encourage some new directions that are consistent with the evolving needs of the American work place.

I would appreciate having your further thoughts on NSF's role in helping to increase the effectiveness of two-year colleges and producing the highly trained technicians that the country increasingly needs in high technology industries, and to know what kinds of programs the Foundation would be willing to pursue. Regardless of whether additional authority is legally required, which is really not the point, the question is: are we on the right track in this proposed bill? Are the program directions that are lined out there, such as the advanced technician training program, the centers of excellence program for two-year colleges, the partnership between secondary schools and two-year colleges in science and math education—are these program directions consistent with your own thinking?

Mr. **Bloch**. Mr. Price, this is a very difficult question because the subject of two-year colleges is very difficult. By the way, let me take exception to one thing.

You talked about 2-year colleges and technician training, both. These might be two different things; 2-year colleges train technicians many times, but they also prepare people to go on, for instance, to 4-year schools, even graduate education and so forth. The role of the 2-year college is a multiple kind of role, and I think we should keep that in front of us.

Mr. **Price**. Yes, I do understand that. I am mainly thinking of the community colleges, those that are often involved in advanced technical training.

Mr. **Bloch**. We have been focusing on the two-year colleges. I think that your criticism is absolutely correct in that we did not focus on that for a long period of time. Your criticism might also be correct that we are not focusing enough on it even today. But I think there is a change in the National Science Foundation by opening up many of the programs that at one time were restricted to 4-year colleges—no doubt about it—to 2-year colleges. In the instrumentation programs, certainly, we have done that across the board and where appropriate.

The second thing that has happened which benefits the 2-year colleges is the fact that we started a major kind of undergraduate program. Much of the curriculum development—I am not going to say all of it, because I am sure somebody can prove me wrong—but much of the curriculum development program as an example is applicable in total or at least in part to 2-year colleges. We hope that we can stimulate that particular use as the result of these programs in 2-year colleges.

In many of the other programs, like the career access programs, faculty enhancement program, and so forth, we are not distinguishing between 2- and 4-year colleges. I think there has been a major change, partly by focusing on 2-year colleges and partially by focusing essentially on new areas where 2-year colleges can benefit, like the undergraduate program.

We had a workshop on the place of 2-year colleges about a year and a half ago to learn from 2-year colleges what their big need really is. They focused on laboratory equipment, but what impressed me when I talked to them personally was that they focused really on the teacher, the instructor, who has a tremendous work load that he or she is dealing with and no capabilities and no time to upgrade himself or herself in order to stay at the forefront of the field where they need to be. I think that is one area where we need to strengthen our program with regard to 2-year colleges.

It is a massive kind of operation, as you realize. There are 1,500 or 1,600 2-year colleges in the United States, so we are talking about a large number and a massive kind of an effort.

I would hope that you realize that we have changed—no doubt about it. You are absolutely right and absolutely correct. At one time, the words 2-year colleges were not in our lexicon.

Mr. Price. I do realize that there have been some very constructive changes, and I am not trying to put you on the defensive about NSF's current role. What I am trying to bring out, though, is some further comment from you about the direction suggested in this draft legislation.

Are we on the right track? Are the kinds of programs that we are envisioning here consistent with what you think NSF's direction ought to be?

Mr. Bloch. I would focus more probably on teacher upgrading, teacher training, and whatever is needed in order to accomplish that. That is what I learned from that workshop.

The second one, which we are already doing, is essentially instrumentation. By the way, for your information, in 1989, we received about 295 new proposals from 2-year colleges. Their success rate was about 21 percent, which is not much different from that of the four-year colleges, which was about 25 percent.

That may not be a great number, but I think it is significant. It is also significant what we were able to fund, for example.

Mr. Price. We have taken some pains in this legislation to design these proposed programs to be consistent with NSF models, with the approaches that are taken in other prototype programs, other programs designed to improve curricula and to improve instructional technologies. So we look forward to working with you as we line out these program directions and refine this bill.

One of the things, of course, that you have brought to NSF from your industrial career and from your experience at the agency is a keen sense of how well or how poorly our educational system is turning out the technical work force that our industries currently require and will require. Much of this is reflected in your statement.

I wonder if you could elaborate that somewhat, and particularly, to comment on the role that industry should play in the training and retraining of our technical personnel?

Mr. **Bloch**. I tell you, I am always impressed when I visit an industrial plant or an industrial laboratory. There is a demand being made today that the operator of a piece of equipment or of a process line specifically.

My experience in the past has been that you can take a high school student and train them to do that. Today, I think that the level of basic knowledge, of understanding, that an individual has to have to operate in that environment is really much different. It is more as a result of a 2- or even a 4-year college kind of education in one of the technology areas. That is required as a first entry point, essentially, into the industrial world, especially in the forefront kinds of industries that are in the forefront of certain technologies.

I think that over the past 10 to 15 years, whatever the time frame is, we have seen this escalation of requirements. That is why I think it is very important that we focus on the 2-year colleges as being the provider of that kind of an education, not exclusively, by the way. I want to stress that. And I think that industry has to realize that, also.

They do, by the way, but I think they have to realize it by essentially supporting 2-year colleges in a way similar to the way they are today supporting 4-year colleges. Some companies do that. I have seen it. I do not know how widespread it is.

It is, again, not something which the community college by itself or a locality or even the Federal Government can handle. I think it has to be a joint kind of a program.

Many of the programs that we are putting in place are focusing on that joint kind of operation of a concern that essentially links schools, industry, State funding agencies, and the Federal Government together. I think that we have to stress that. There is no doubt about it—we are depending more and more on the output of 2-year colleges for the needs of industry than we did in the past.

Mr. **Price**. Certainly, that is consistent with what Mr. Valentine and I learned at the start of this process of developing this legislation when we had hearings in North Carolina. The head of the largest firm in the Research Triangle Park indicated to us that the day was not far distant when they would have virtually no jobs for a person without at least 2-years beyond high school and that most jobs would require a great deal more than that.

Partly in response to that situation, that particular firm and many others have developed cooperative relationships with the local community college system that have helped them meet their work force needs. In this legislation, of course, we are trying to respond to that situation and to upgrade the quality of those technical training programs to develop some prototypes to make this kind of effort more widespread.

Thank you, Mr. Chairman.

Mr. **Valentine**. Thank you very much.

Mr. Bloch, you have been in that seat now for about 2-hours, and we apologize for that. Part of this, of course, is a reaffirmation of our faith in the democratic process from there and from here.

I want to ask one last question that is perhaps over-simplistic. In a few hours, if all goes well, I will have the opportunity to speak to a commencement exercise at Jordan High School, which is almost within the shadow of Duke Chapel and a few miles from Chapel Hill.

All of us either understand or can imagine the impact that the National Science Foundation has on those two universities, junior colleges, and other institutions of higher learning. Can you tell us in a few words how you reach, if you do, directly into the educational atmosphere in a high school, such as this one and others in that State and other States in the Union?

Mr. **Bloch**. Are you asking how NSF does it, or how one should reach into that high school?

Mr. **Valentine**. How NSF does now.

Mr. **Bloch**. We certainly do it through our programs, hopefully, and through the output of our programs, our teacher training programs, our curriculum development programs for a high school curriculum.

Mr. **Valentine**. And those are handled through the State? Or do you go directly to these schools? The services of your institution are directly available—they could make contact at Jordan High School with the National Science Foundation and get assistance in planning and improving a science department in a high school, is that right?

Mr. **Bloch**. I don't know if I should answer yes to that, or not. [Laughter.]

Let me explain in my own words.

Our grants can go to a grantee who is in either a high school or in a university to develop a certain curriculum. It can go either way.

Many times, you see essentially a combination of things happening: that a high school is involved, that a publisher is involved, and that a grantee is involved, wherever that grantee might be. Jointly, they develop something, test it out, and then publish it, in terms of a high school curriculum.

So I do not think we have one particular path. That is the point I wanted to make. I think that we are flexible enough so that we have many paths. Many times we give a grant to a professor in a university who has a good idea and wants to develop something and therefore create a new curriculum program or project for a high school. There are many ways that we are making that connection.

We have a program that focuses on high school students, bringing them out of high school during the summer and letting them spend a few weeks in a university to learn something in terms of research and the nature of what is going on and, at the same time, broaden his interest or her interest in education. That is another way of reaching in there. We are not doing that directly by focusing on that high school student, but we are essentially focusing, again, on a grantee, be it a university professor or what have you. That in turn then focuses on the high school student.

Many times that student does not see NSF in a direct kind of way. That was the point I wanted to make.

Mr. VALENTINE. Yes. I would like to have an opportunity to pursue that with you in private conversation, but I will not take any more of your time and the subcommittee's time.

If there are no further questions or statements, I will say again that I thank you, Mr. Bloch and you, Dr. Williams, for your time and patience.

We will now turn our attention to panel number two, which consists of Dr. Charles Glassick, Vice President, Carnegie Foundation for the Advancement of Teaching, Princeton, New Jersey, and Dr. Mel George, President of St. Olaf College, Northfield, Minnesota.

Dr. George, just think of me as Tim Penny and not Tim Valentine for a minute.

Dr. GEORGE. Sir, you look amazingly like him. [Laughter.]

Mr. VALENTINE. You just insulted him, but I'm sure he will forgive you. He was here and I am sure you met him. He had to leave on other business, but his very generous statement concerning your appearance here will be placed in the record. I give you your Congressman Penny's special welcome, also.

[The prepared statement of Mr. Penny follows:]

Mr. Chairman and colleagues, today I would like to introduce Dr. Melvin George, the President of St. Olaf College, located in Northfield, Minnesota, in my congressional district.

Doctor George's academic career includes 25 years in major public research universities as teacher and administrator. He served as Associate Dean for Science of the graduate school of the University of Missouri-Columbia, as dean of the College of Arts and Sciences at the University of Nebraska, and then as vice president for academic affairs of the four-campus University of Missouri system. Doctor George is a member of the Advisory Committee for the Science and Engineering Education Directorate (SEE) at the National Science Foundation (NSF). He has life-long commitment to and involvement in science and mathematics education. Mel speaks today as the president of one of the nation's premiere undergraduate institutions for science and mathematics.

It is my great honor and personal pleasure to present my friend and advisor, Mel George to the Subcommittee. Thank you, Mr. Chairman.

Mr. VALENTINE. We are happy to hear from you gentlemen at this time. Your statements will appear in the record as presented to us, and I invite you to summarize if you feel that you can appropriately do so.

Dr. Glassick?

STATEMENT OF DR. CHARLES E. GLASSICK, VICE PRESIDENT, CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING, PRINCETON, NJ

Dr. GLASSICK. Thank you, Mr. Valentine. I appreciate the opportunity to address the subcommittee.

I am going to speak to the educator award program. I want to say first that the Carnegie Foundation endorses this program vigorously, believes it is a needed program, and the reasons for that were excellently summarized by the Subcommittee Members. I will not repeat them.

As you have indicated, the full title of the Carnegie Foundation is Carnegie Foundation for the Advancement of Teaching, and we are intimately concerned and involved in teaching in the United States, and in recent years, most particularly, at the undergraduate level. So we very much endorse the opening remarks which Mr. Brown made on this subject.

Ernest Boyer, President of the Foundation, has recently published, "College: the Undergraduate Experience," and I will not summarize our other publications which appear in my statement. The point which is pertinent to the educator awards program is that we are now working on the role of scholarship in colleges and universities, believing, as Mr. Brown and Mr. Bloch said earlier, that research has become so dominant that it has crowded teaching out of a central place in many of our institutions. The Carnegie Foundation believes that the definition of acceptable and rewarded scholarship in the universities across our nation must be expanded.

First of all, let me say that we applaud research as scholarship. We believe that research must continue in our country. Our nation needs it. We also believe that our educational process needs to honor and reward broader forms of scholarship in these institutions, needs to reward additional ways of knowing. My statement gives some summary to this. I will just mention the forms of scholarship that we advocate.

First of all, we believe that scholarship of discovery, or research as it is now known, should continue to be rewarded and recognized, but also that prestige and reward should be given to the scholarship of integration of knowledge, the scholarship of application of knowledge, and also the scholarship of teaching of knowledge. It is this latter that I want to speak to very briefly today.

In your bill, you refer to other scholarly activities. Simply, this may be a harbinger of the idea that teaching is also a form of recognized and rewardable scholarship.

We are not talking about presentation techniques, not the handwaving, voice modulation skill of capturing attention as part of teaching. We are talking about the intellectually rigorous problem solving that prepares the materials and prepares for teaching. The use of correct technology, for instance, the use of right metaphor or the right analogy, so that more students may learn science well and so that more students might be attracted to science.

For instance, we need to learn to convey a scientific principle to a non-science major without trivializing the science. In order to do this, we need to know how those students perceive science. Sometimes there is a gender difference in the way science is looked at, and we need to know how those students learn abstract concepts, which may be different, as I have said, for women and sometimes even for minorities.

We need to go beyond the learning of data, rules, and facts into the development of critical thinking skills, thinking clearly, developing the joy of lifelong learning, and this requires, according to Lee Shulman of Harvard, a scientist to do this, to teach science. It is something that can not be learned in a school of education and can not be learned in a center for teaching development, although we applaud such centers.

To take an example from science since I am a chemist—should light be portrayed as a wave or should light be portrayed as a particle or as an epiphenomenon? Should light be portrayed as an electromagnetic radiation, or should light be taught as a mental event? Well, the answer is, yes, it should be portrayed as each of these depending upon the sophistication of the student, the purpose of the course, and other factors.

We believe that there is a scholarship which lies behind the presentation of knowledge, which brings in the student, the student's learning, the student's background, the student's culture, so that certain values and goals can be achieved in the teaching. We believe that the bill which you have proposed here and the award system that you have proposed could, if the criteria are chosen properly, endorse such forms of teaching and indeed provide concepts that could be used and reused in classroom after classroom, laboratory after laboratory, perhaps for the remainder of this century.

We heartily endorse the bill and look forward to its passage. Thank you, sir.

[The prepared statement of Dr. Glassick follows:]

REMARKS ON UNDERGRADUATE SCIENTIFIC EDUCATION TO THE CONGRESSIONAL PANEL
JUNE 7, 1990

SCIENCE, ENGINEERING, AND MATHEMATICS EDUCATOR AWARD PROGRAM

CHARLES E. GLASSICK
THE CARNEGIE FOUNDATION FOR THE
ADVANCEMENT OF TEACHING

I want to thank the committee for the opportunity to present our views on scholarship and appreciate being a member of the panel with Mel George, a distinguished educator in both public and private higher education and also to join the distinguished president from the University of California at Irvine.

As you know, the full title of The Carnegie Foundation is "The Carnegie Foundation for the Advancement of Teaching." We are concerned about the quality of teaching at all levels of education. Most recently, our publications have focused on the undergraduate teaching. A few years ago, Dr. Boyer published *College: The Undergraduate Experience in America*. In this book he lays out our view of undergraduate education and the values on which it should be based. Dr. Boyer, with Art Levine, published *A Quest for Common Learning*, which is the Foundation's view of general education at the undergraduate level, and, more recently, Dr. Boyer published *Campus Life*, which defines the values which we believe should be associated with the formation and formulation of "community" on campus.

Now, even as I left this morning, Dr. Boyer was working on the role of scholarship in colleges and universities and an extent to which scholarship serves the teaching of undergraduates. Carnegie Foundation's position is that the definition of scholarship now extant in our colleges and universities--that is, scholarship defined solely as research followed by publication--is too narrowly defined to serve the broad fabric of higher education.

First, be assured that we applaud research; that we applaud discovery. It must continue at its high level--our nation depends upon it. We believe, however, that to serve the faculty, the students, and, most importantly, knowledge, higher education must recognize and reward other forms of scholarly activities. We encourage colleges, universities, and learned societies to expand the definition of scholarship and to acknowledge and reward additional ways of knowing.

Forms of scholarship which Carnegie Foundation advocates are:

1. The scholarship of discovery or research; that is, scholarship as we now know it.
2. The scholarship of integration of knowledge: a form of scholarship that is increasingly needed as disciplines become more fragmented and real problems become more complex.
3. The scholarship of application of knowledge. This is particularly pertinent in professional schools, such as architecture.
4. The scholarship of the teaching of knowledge.

It is, of course, this latter form of scholarship that is most pertinent today, although all forms relate to the discussion. In the bill which we are addressing, you use the phrases "other scholarly activity" or "scholarly activities in teaching." Under selection criteria you ask the applicant to "make a significant contribution to undergraduate science education and have an ongoing program of research or other scholarly activity." The Carnegie Foundation maintains that the scholarship of teaching is a legitimate and appropriate form of scholarship to be awarded and rewarded in this program.

When we refer to the scholarship of teaching, we are not talking about techniques or presentation methods. We're not discussing the hand-waving, the voice modulation, the skill of capturing attention, but rather we are talking about the intellectually rigorous problem solving that goes into preparation of curricular materials and presentations. For instance, choosing the right metaphor or right analogy requires an understanding of how students learn, particularly how they learn science. An ability to convey a scientific principle to a non-science major without trivializing the science requires an appreciation of how those students perceive science and how they learn abstract concepts. The integration of an appreciation of how students learn, their level of sophistication in science and the subject matter itself requires intellectual creativity, which is, we claim, a form of scholarship.

We would also maintain that there is a synoptic function in the teaching of science. Bringing recent advances in the field to the basic principles, and then teaching them as an integrated whole instead of a set of disconnected facts, requires intellectual concentration which is clearly scholarly in its form and substance.

Finally, to go beyond the learning of data, of rules, of facts into the development of critical thinking skills and ability to think clearly, problem-solving skills, ability to follow instructions, commitment to careful and accurate work, and perhaps, more importantly, to develop a life-long joy of learning science and such higher values as honesty or personal responsibility requires a knowledge of the subject area that can be brought to teaching only by the scientists themselves. Lee Shulman of Harvard has put forward the thesis that effective teaching is content-specific. In order for students to make the appropriate connections and develop the appropriate skills, teachers must know the subject area. For instance, should the history professor represent history as chronology, as biography, as recreation of the past, as a moral lesson, as the predictor of the present, or as a manifestation of some deep underlying force?

The answer is yes. History should be presented as each or any of these; it depends on the particular topic, the sophistication of the student, the purpose of the course, and other factors. An integration and interpretation of all these factors in order to know how to teach the subject most appropriately is clearly an intellectually creative act, not to be learned in a school of education, not to be learned in a center for teaching development (although we applaud such centers), but can finally be brought to the teaching process only by the specialist himself or herself. I could make a similar analogy in science.

Obviously, we therefore applaud this bill. If these awards are made to aid and abet the kind of scholarship I have described, then major and significant science education advances will be achieved--not just for the faculty themselves who are involved, but materials will be developed, teaching techniques and concepts will be proposed that can be used and reused in classroom after classroom, laboratory after laboratory, for perhaps the remainder of this century.

I encourage a continued, even increased, emphasis on the scholarship of teaching.

Thank you for the opportunity to speak this morning. I'd be pleased to answer questions.

Charles E. Glassick
June 7, 1990

Mr. **Valentine**. Thank you, Dr. Glassick.
Dr. George?

STATEMENT OF DR. MELVIN D. GEORGE, PRESIDENT, ST. OLAF COLLEGE, NORTHFIELD, MN, ON BEHALF OF THE ASSOCIATED COLLEGES OF THE MIDWEST, THE GREAT LAKES COLLEGES ASSOCIATION, THE CENTRAL PENNSYLVANIA CONSORTIUM, AND THE ALLEGHENY COLLEGE AND REED COLLEGE

Dr. **George**. Mr. Valentine and members of the committee, I am delighted to be here. I come from a rather unusual background in that I spent 25 years of my life in big public research universities as a professor of mathematics and an administrator of science research and graduate programs before going to one of the Nation's fine liberal arts colleges which is strictly undergraduate, St. Olaf College.

I represent a group of about 30 fine liberal arts colleges which are strictly undergraduate in my testimony today. I am also a member of the National Science Foundation's Science and Engineering Education Advisory Committee. I do not speak for that group today, but I simply note that we have two days of meetings on Monday and Tuesday which should be very interesting in their discussions indeed, particularly after hearing the discussion this morning before the subcommittee.

I want to note in speaking to the bill that it is important for the committee to keep in mind that there are different kinds of institutions. I tried to make the point in my written testimony that large universities in which there is a need to address the imbalance in the faculty reward system have one set of problems, and colleges like the ones I represent, in which teaching does predominate and fine research is still done, have other kinds of problems to do science education more effectively. I have listed some of those in my testimony and hope the committee will look at those as you continue your work on this bill.

I am very grateful, on behalf of all of us whose lives have been committed to science education, to the Congress generally and to this committee and subcommittee, in particular. It is indeed the leadership of the Congress that has resuscitated science education in the last 10 years. Indeed, members of the committee were right, I think, in pointing out that the Congress has been always in front of the Administration on this issue.

Mr. Walgren was also absolutely correct in pointing out that while percentage increases may sound impressive, National Science Foundation funding for education is still only about half of what it was in terms of real dollars and in terms of percentage of budget back at its height. It is even farther away from the goals of the Neal Report.

I am delighted that Homer Neal is going to appear in the next panel to remind you of the vision that we ought to have for science education in this country. I am grateful for this hearing, and I invite the committee to have a hearing on one of our liberal arts college campuses in the Midwest, to perhaps talk to some faculty members and see how effective teaching and good research can be done at the undergraduate level without conflict.

I want to turn very quickly to the bill, which I support. I was asked to speak particularly about Section 6 on undergraduate scientific education and the science educator portion.

I have two comments. I believe that the undergraduate level is the best window of opportunity for this nation to improve science education, and I say that for two reasons. It is at the undergraduate level that teachers are prepared for the elementary and secondary classrooms. That is a very important point. It is also at the undergraduate level, I believe, that we have the best opportunity to do something broad and long lasting in science literacy for all the population. It is also at the undergraduate level that decisions are made by students as to whether or not to go to graduate school and go into scientific careers.

I see that as a very important opportunity for the Nation, and I am very grateful that you have identified a whole section of this bill for undergraduate science education. I do note, however, that in the findings section of the bill, the word "undergraduate" is not mentioned. I call that to the committee's attention and hope that as you rework the bill, you would look at those findings and emphasize a little more undergraduate education.

In the section on elementary and secondary education, I hope you will emphasize a little more of the preparation of teachers. I think that all the curricular improvement programs, all the computers in the classroom, are wonderful, but unless you get teachers in the elementary classrooms who really understand why the sky is blue and can get kids excited about knowing why the sky is blue, you will not have done the job. That preparation level is very important.

In Section 6, the goal was to change the faculty reward system. In many institutions in this country, that needs to be done. Let me suggest that Section 6 is a very good program. I hope that the committee bill will keep it in and that the bill will pass.

I suggest also that the criteria should be modified in a couple of different ways. Simply to recognize people who are doing good teaching is a laudable goal and would have a great morale boost for people who are laboring in the trenches, but your criteria are all individual ones dealing with the applicant.

I think that if you were to have some institutional criteria which would force the institution in which the applicant lives to buy into, if you like, the proposal. You could ask the institution what it will do to see that the curricular innovations which would be funded under Section 6 can actually be carried out. It would be very interesting if you asked the institution to supply data about where the applicants salary and rank fits in with the other members of his or her department to see if, in fact, this great teacher is being rewarded well in the normal way institutions reward people. You could convey some very interesting messages.

I think that the kind of leverage that the National Science Foundation tried to use in Important Notice 107—and I was dismayed to hear that there are attacks on that language. I think that language of asking research scientists to indicate the impact that their program might have on education is a splendid idea, and I am appalled that people would be paranoid about that. That kind of leverage, I think, exerts much more influence on an institution than simply an award program without that kind of institutional criteria.

Mr. Chairman, I have made some specific suggestions in my written testimony about kinds of institutional criteria that you might want to consider adding that I think might get more bang for the buck in this very worthwhile program.

Thank you.

[The prepared statement of Dr. George follows:]

Statement by

Melvin D. George
President
St. Olaf College

on behalf of

The Associated Colleges of the Midwest,
The Great Lakes Colleges Association,
The Central Pennsylvania Consortium,
Allegheny College and Reed College

on the

Draft Subcommittee Bill dealing with programs at the National Science Foundation for the promotion of science and technological literacy; for the improvement of science, mathematics, and engineering instruction; for the expansion of the pool of skilled technicians in advanced technology fields; and for other purposes.

before the

Subcommittee on Science, Research and Technology
Committee on Science, Space and Technology
U.S. House of Representatives

on

June 7, 1990
Room 2318, Rayburn House Office Building

INTRODUCTION. I am Melvin D. George, President of St. Olaf College in Northfield, Minnesota. I am a mathematician; my academic career includes 25 years in major public research universities as teacher and administrator. Before coming to St. Olaf as president in 1985, I served as associate dean for science of the graduate school of the University of Missouri-Columbia, as dean of the College of the Arts and Sciences at the University of Nebraska, and then as vice president for academic affairs of the four-campus University of Missouri system.

Since 1989 I have been a member of the Advisory Committee for the Science and Engineering Education Directorate (SEE) at the National Science Foundation (NSF). However, I present these comments, not as a representative of that committee, but as one who has had a life-long commitment to and involvement in science and mathematics education. I speak today as the president of one of the nation's premiere undergraduate institutions for science and mathematics. I speak also for our peer institutions in the groups represented by The Independent Colleges Office in Washington, including member institutions of the Associated Colleges of the Midwest (to which St. Olaf belongs), the Great Lakes Colleges Association, The Central Pennsylvania Consortium, Allegheny College (PA), and Reed College (OR).[1]

I want to express my appreciation to the Congress, and specifically to this House Subcommittee, for your unstinting efforts, past and present, to bring science and mathematics education to the current level of support within the NSF. As you well know, fewer than ten years ago, NSF support for programs related to education was minuscule. This Subcommittee, responding to urgings from the undergraduate community and rejecting the desires of the executive branch of government, almost singlehandedly brought science and mathematics education part way back from the grave. I say part way because it is imperative that we continue to be alert to the need to sustain and increase the level of support for undergraduate programs within NSF and throughout the federal government.

The foundation is currently in some turmoil and the future direction of its education programs is not clear. There are those who would turn the NSF into a national research foundation, overlooking the dual mandate of the NSF to focus on research and education in the sciences. This would be a mistake. I believe we now must build on the strong programs currently in place in the foundation, particularly in the Undergraduate Science and Engineering Education Division in the SEE Directorate, and in the distributed programs.

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[1] The members of ACM include The Colorado College; Knox, Lake Forest and Monmouth in Illinois; Coe, Cornell and Grinnell in Iowa; Carleton, Macalester and St. Olaf in Minnesota; and Beloit, Lawrence, and Ripon in Wisconsin. The members of GLCA are DePauw, Earlham and Wabash in Indiana; Albion, Hope and Kalamazoo in Michigan; and Antioch, Denison, Kenyon, Oberlin, Ohio Wesleyan and the College of Wooster in Ohio. The members of CPC are Dickinson, Franklin & Marshall and Gettysburg in Pennsylvania.

THE FINDINGS. The Findings that introduce the Draft Subcommittee Bill under discussion today are significant, both for what they say and for what they do not say. The programs proposed in this Draft Bill are based on Congressional realization that "...the achievement of scientific literacy by all Americans...is essential...the United States faces a potential shortage of scientists, engineers, and science, mathematics, technology teachers...," and that Americans "...have been hampered by low levels of educational attainment in science and mathematics." I agree.

I am disappointed and perplexed, however, that the Findings mention only primary and secondary education, but do not include an explicit commitment to the strengthening of the teaching of science and mathematics at the undergraduate level. I particularly call to the Subcommittee's attention the absence (in Finding #10) of any mention of the education of individuals planning to become primary and secondary teachers. That education occurs at the undergraduate level. It is my conviction that, although many new and redesigned programs for elementary and secondary teaching could be implemented, unless the structure of undergraduate education of prospective elementary and secondary teachers is changed, this nation will continue to have science and mathematics teachers in grades K-12 who are not effective because they neither understand nor are comfortable with science and mathematics concepts.

I urgently encourage you to reconsider the Findings of the Bill. Unless undergraduate education is explicitly included, in particular the education of future science and mathematics teachers, you will have missed one of the critical windows of opportunity in our current crisis in science and mathematics education.

RESEARCH AND TEACHING. I want to make it clear that I recognize that research in science and mathematics is essential, if, as stated in the Findings of the Draft Subcommittee Bill, this nation is to "...develop products and services which will compete...and improve the American standard of living." I also would like to stress that research and teaching at the undergraduate level are inextricably related.

This integral relationship between research and teaching has implications as we consider the Draft Bill before us and consider how to improve existing programs for science, mathematics, and engineering education within the NSF.

As we contemplate changes or additions to NSF programs, I do not want to see education programs considered in isolation from other activities at NSF. I do not want NSF educational programs administered by persons without a strong background in science; at the same time, I do not want decisions about NSF educational programs made by persons without demonstrated experience in and commitment to the classroom, to research partnerships with students, to ongoing curriculum development, and to the learning community which is the optimum undergraduate environment for the best in science and mathematics education.

THE UNDERGRADUATE ENVIRONMENT. There are places where such optimum learning environments exist, places where teaching and research come together in practice as well as theory. Let me tell you, for example, some facts about St. Olaf College which influenced my decision to leave a major research university and move to St. Olaf five years ago. As I was considering this opportunity, I discovered that, in May 1984, the College had graduated many more students with majors in mathematics than had the entire University of Missouri system, with its 52,000 students, 18 times more than St. Olaf. On a regular basis, the number of mathematics majors in a St. Olaf graduating class has increased significantly over the number of declared mathematics majors in that class upon entering.

I was also pleased to find that St. Olaf was representative of the cadre of select liberal arts colleges in which full professors of mathematics, physics, chemistry, and biology are actively involved in classrooms and laboratory teaching; where undergraduates are actively engaged in research projects with professors; where St. Olaf's commitment to teaching is carried out through institutional procedures relating to hiring, and to determining faculty salaries and promotion.

I still find this situation astonishing in the context of American higher education today. St. Olaf's ability to attract and sustain student interest in science and mathematics is duplicated in similar institutions across the country. Because of such an environment, colleges like ours send a disproportionate number of graduates into precollege teaching and on to graduate schools in science and mathematics. We are significant players in the national effort to strengthen science and mathematics in the total educational continuum.

This undergraduate environment is what drew me to St. Olaf and what brings me here today. I am deeply convinced that undergraduate education is the critical arena in science and mathematics education. The undergraduate level is where graduate students--those who go on to careers as researchers and college faculty--are prepared. The undergraduate level is where the nation's elementary and secondary teachers are equipped. It is at the undergraduate level where we prepare the citizens of tomorrow, those who will be making critical decisions in a world wherein science and technology are of increasing importance.

The undergraduate level, in my opinion, provides the best opportunity for making needed and effective change in science and mathematics education and research in this nation. Changes will not happen at the elementary and secondary level until changes are made in teacher education at the undergraduate level. And changes in graduate education, while necessary, come too late to affect the career decisions of the great majority of potential scientists and mathematicians.

FACULTY REWARD SYSTEM. It is precisely in the faculty reward system at most institutions, particularly the large universities, that problems with undergraduate education begin.

That this Subcommittee recognizes this reality was demonstrated by Mr. Valentine's letter asking me to review section 5 of the Draft Bill "...in light of its overall goal, which is to help redress the imbalance between teaching proficiency and research performance in the faculty reward system in colleges and universities."

I am delighted that a representative from the Carnegie Foundation for the Advancement of Teaching joins me on this panel today. (I should also point out that Dr. Glassick was, until recently, president of the one of the colleges in the Central Pennsylvania Consortium.) The Carnegie Report, "Campus Life-In Search of Community," has correctly identified the general malaise affecting most segments of American higher education and correctly calls for RESTORING THE CENTRALITY OF TEACHING, focusing on the same issue identified by this Subcommittee in section #6 of the Draft Subcommittee Bill.

This is a laudable goal, vital for most American institutions. But many colleges already give primary attention to teaching in their faculty reward structure. The kind of liberal arts colleges which I represent today, while certainly not perfect, do not suffer an imbalance in the faculty reward system and have needs not addressed in this Draft Bill. Is there a place for these institutions in this new program? I hope so.

THE PROPOSED SCIENCE EDUCATOR AWARD. Let me turn here to the specific purpose of my testimony, section 6 of the Draft Bill. This section is entitled "Undergraduate Scientific Education" but it contains only a single new program. Although the proposed program has much merit, it is ironic that in the section dealing with this critical issue nothing is said about strengthening existing programs at NSF; it merely proposes an additional effort.

Merely to add programs at the margin will not have much effect. It does little good to add new programs without giving full attention to existing programs (including funding), without considering the context in which programs are to be administered, or how to change the mind-set (the reward system if you will) of those with responsibility to develop and implement those programs. Failure to recognize this may be one of the reasons for the current situation at NSF.

Having said that, I am very glad you are considering the establishment of a means to recognize and encourage faculty with demonstrated excellence in undergraduate education comparable to that currently available to recognize faculty with experience and potential in research areas. Such an award can give visibility to and ultimately strengthen undergraduate science and mathematics education.

However, I have a few suggestions and two major concerns.

The suggestions are:

a) Change the title of the proposed program to something which has prestige equal to that of the "Presidential Young Investigator" Award. How about the "Presidential Science Educator Award?"

b) An award of three-months salary (assuming that it is the maximum allowed for the total three-year period) is not enough incentive or recognition. If this award is to be credible, the financial consideration has to be increased.

My major concerns, however, follow from my earlier analysis of 'what works' within the liberal arts college environment. Currently the Draft Subcommittee Bill outlines selection criteria which relate to the individual applicant. Nowhere in the current Draft Bill do I find criteria for establishing the record or demonstrated potential of the applicant as an exemplary teacher, both in and out of the classroom. Such language needs to be specific in a final bill.

In addition, it is critical, if this proposed program is to influence "the faculty reward systems in colleges and universities", that specific institutional criteria be added about the environment in which the applicant carries out responsibilities as teacher/scholar in all areas of campus life. For example, additional criteria could include:

a) an analysis of the sponsoring institution's commitment to carrying out the curriculum enhancements funded through the award. The willingness of the institution to allow--and even encourage--the recipient to influence science and mathematics education within his or her institution and within the larger educational community should be explicit;

b) an analysis of the applicant's salary compared with the salaries of his or her departmental peers, persons with perhaps a greater commitment to research than to teaching. This criterion would help insure that this new award is not a substitute for the normal institutional reward system;

c) evidence that the institution has made or is making structural changes across the board in teaching assignments, including class sizes, general allocation of resources committed to teaching, including faculty and curricular development; and

d) an analysis of criteria for and evidence used in hiring, promotion, tenure decisions, salary determinations, e.g., that demonstrate an increasing commitment to teaching at the undergraduate level. Institutions should be held accountable for the effectiveness of teaching, and evaluation of teaching must be central to personnel decisions.

Without such institutional criteria being a central feature of this new program (and I could have listed others), I fear this proposed program will be only a peripheral and marginal program. There would be a dinner at the institution to honor the recipient; then, if the institution is a large university, he or she would likely disappear into the backwater ranks of associate professors who are trotted out now and again as evidence of the institutional commitment to teaching, but who always end up on the bottom of the salary and prestige lists.

I may sound like a cynic; I am not. But 25 years in major research universities have made it clear how the system works and how much is needed to change it. The program you are proposing, with some adjustments and careful consideration of the larger context, could provide an even more powerful leverage on a total system rather than being one more, very nice, but fundamentally marginal recognition of good work being done--by many faculty members at institutions like mine with full support of administrators and colleagues, and by the few hardy and brave souls in many other colleges and universities across the country who struggle in virtual isolation to do a good job at undergraduate education.

CONTEXT FOR UNDERGRADUATE SCIENCE AND MATHEMATICS EDUCATION. Equally important, I would like to suggest that, in addition to considering this new program, this Subcommittee consider means to make changes and to provide financial and other support in key areas at NSF (and in other federal agencies) if the ethos of the undergraduate experience in this nation's colleges and universities is to be changed meaningfully.

What must be done if science and mathematics education at the undergraduate level is to be improved?

a) The reward structure at most institutions must give more weight to effective teaching. This is the central point in your Draft Bill and I applaud the Subcommittee for recognizing that;

b) More money must be found for instructional scientific equipment, including equipment for those laboratories in which students first experience science on the college campus AND for the research training which is an essential ingredient in the education of the scientists and science and mathematics faculty of the future;

c) Adequate support must be available to address the current needs for modernization of facilities used for teaching science and mathematics. Over the objections of the NSF, a start has been made here, and I commend this Subcommittee for their vigilance in keeping facilities as a priority concern. I urge you to consider expanding such facilities modernization grants to include spaces designated as teaching spaces, as well as those used primarily for research and research training. I support the current efforts to leverage support from federal, state, and private sources to meet this critical need;

d) The educational program for prospective teachers in elementary and secondary schools must be drastically modified to put more emphasis on content and less on pedagogy. We simply must not put teachers into precollegiate classrooms who cannot add fractions, who do not understand why the sky is blue;

e) School boards and PTA's must be influenced to take a more active role in improving science and mathematics education in the schools for which they have responsibility. I am hopeful that the new NSF program, the States Initiatives Grants Program, will produce some interesting proposals to leverage some powerful local agencies;

f) Research opportunities for undergraduates should be greatly increased; these are the 'farm clubs' for future science and mathematics educators and researchers. These research opportunities should be designed explicitly to complement the ongoing undergraduate experience of the student during the academic year;

g) Curriculum development activities in all disciplines at the undergraduate level must be expanded, again with a clearer sense of the larger context in which any one specific project will function;

h) Ways must be found to help graduate students and new Ph.D's learn how to teach effectively, how to balance a research agenda with a career as teacher. In that connection, I invite your attention to the model currently functioning at St. Olaf, funded by the Fund for the Improvement of Post-Secondary Education, which brings post-doctoral teaching fellows into our mathematics department;

and finally,

i) Small science must be given its rightful due. We must remember that this nation gets a significant "bang for the bucks" by providing adequate support for small science, for faculty and curriculum projects such as we are discussing today, as well as for research projects. If you look at the record of federal grant support to the nation's colleges and universities in response to the Sputnik crisis, to a large extent, it was the multiplying effect of countless small grants, grants for curricular change, for research experiences for high school and college students, and undergraduate faculty that provided the scientific talent pool in the 1970's, a pool on which we still rely today, but which is both aging and shrinking.

In all these and other ways, the federal government can intervene as nudger, as prodder, as provider of incentives and support in the critical effort to "...help redress the imbalance between teaching proficiency and research performance..." and, ultimately to ensure the continued competitiveness of America in science and technology.

SUMMARY. One good example of how existing programs can be reshaped to do this prodding is the recent NSF Important Notice #107, which requires that proposals seeking support for research activities demonstrate how that project relates to the 'pipeline crisis', by indicating numbers of graduate students with whom the principal investigator is and has been involved. This was a significant step at NSF in recognizing the importance of science education and the link between research and teaching. A next step ought to be to ask for the number of undergraduate contacts!

Congress should take particular interest in how the NSF is implementing this Important Notice, and how decisions about research grant awards change in the next few years because of it.

This is one example, a good one--at least I hope it will prove to be--of how the federal government can influence institutions in ways that are likely to be even more significant than any individual new program that might be added. The award proposed in section 6 of the Draft Subcommittee Bill under discussion today could have a similar influence, I believe, with the changes I have proposed.

Thank you for the opportunity to present these remarks.

MELVIN D. GEORGE

CURRENT POSITION: President, St. Olaf College

ADDRESS: St. Olaf College
Northfield, Minnesota 55057

BIRTH: February 13, 1936, Washington, D.C.

MARITAL STATUS: Married, two children

EDUCATION:

B.A. (With Highest Distinction), Northwestern University, 1956
Ph.D., Mathematics, Princeton University, 1959

ACADEMIC POSITIONS:

1959-60	University of Maryland Research Associate, Institute for Fluid Dynamics and Applied Mathematics	
1960-70	University of Missouri-Columbia	
	Assistant Professor of Mathematics	1960-64
	Associate Professor of Mathematics	1964-67
	Professor of Mathematics	1967-70
	Associate Chairman, Department of Mathematics	1966-67
	Associate Dean, Graduate School	1967-69
Fall, 1969	Texas A&M University (on leave from University of Missouri)	
	Visiting Research Professor, Institute of Statistics	
1970-75	University of Nebraska-Lincoln	
	Dean, College of Arts and Sciences, and Professor of Mathematics	
1975-85	University of Missouri	
	Vice President for Academic Affairs and Professor of Mathematics	1975-85
	Interim President	July-December, 1984
1985--	St. Olaf College	
	President and Professor of Mathematics	

HONORS, MEMBERSHIPS, CONSULTANTSHIPS:

Phi Beta Kappa
Sigma Xi
NSF Predoctoral Fellowship, Princeton University
Danforth Associate, 1965--
Elected honorary member of Innocents Society (University of Nebraska Senior Men's Honorary), 1973
Member, Board of Directors, Council of Colleges of Arts and Sciences, 1974-75
Elected honorary member of Mystical Seven (University of Missouri-Columbia Senior Men's Honorary), 1977
Member, Board of Directors, IPS Computer Marketing Corporation (New Jersey), 1980-88
Member, Board of Directors, Centerre Bank of Columbia (Missouri), 1981-85
Member, Board of Directors, Spring Hill Center (Minnesota), 1985-88
Member and initial Chairman, Regent Candidate Advisory Council, established by the Minnesota Legislature to recommend candidates for Regents of the University of Minnesota, 1988-94
Member, Advisory Committee for Science and Engineering Education, National Science Foundation, 1989--
Member, Executive Committee, Minnesota Private College Council Board of Directors, 1989--
Consultant-Evaluator, North Central Association Commission on Institutions of Higher Education, 1981--
Member, Accreditation Review Council, North Central Association Commission on Institutions of Higher Education, 1989--
Member, Board of Directors, Association of American Colleges, 1990--

Mr. **Valentine.** Thank you both.

Dr. Glassick, is there a danger that these awards will be viewed as second tier recognition when compared to the rewards of research? What do you say about that? Does that present any problem?

Dr. **Glassick.** Yes, I think it is an issue. It is, in fact, a statement by the Congress and then eventually by the National Science Foundation that teaching is valued. That is one of the reasons we endorse the bill so vigorously.

It will raise the level of teaching and raise the prestige with which it is viewed if the Congress comes forward with this bill. It also relates a little to the criteria that are used in awarding it, too.

Mr. **Valentine.** Are there ways in your opinion to alter research grants so as to encourage teaching?

Dr. **Glassick.** We at the Carnegie Foundation would answer that with a definite yes, in the sense that we are dealing with the definition of research and the definition of scholarship, and would simply advocate that scholarly inquiry into teaching is as valid a form of scholarship as is research into an electronic cell or some chemical mechanism.

That debate will be taking place very soon. Our publication is due in the fall, and we expect higher education to be debating this very issue that we are talking about here.

Dr. **George.** Mr. Valentine, I would respond, agreeing with Dr. Glassick, that research and scholarship of that kind is valuable, but I think that in another sense, yes, you can do something to encourage research grants to get more involved in teaching. I think the NSF Important Notice 107 was a start in that regard.

One of the clear indications we have of ways to improve the scientific pipeline in this country is to get undergraduates, and even high school students, involved in research activities at an early age. If you get students early on into hands-on research, you get them excited about science. One of the great things that happens in good undergraduate institutions is that freshmen and sophomores get into research laboratories very early with real teachers.

I think that the NSF needs to continue to ask, as it gets in research proposals, not only what does this research have to do with the training of graduate students, but also what does this research have to do with the education of undergraduates? There is a kind of theory abroad in large universities that no legitimate research starts until the graduate level. That is not true. One can do very good research with undergraduates and simultaneously get them excited about science.

Mr. **Valentine.** I think that those are excellent points and that leads me to a question that is not on my list. There is in this country, I think—I know there is in my home State—a tremendous difference between the quality of education delivered at the college level and that which is delivered at the precollege level. There is even a marked difference in the monetary contribution, proportional to other States, that has existed there historically.

It is easy to understand how the National Science Foundation and the academic and educational communities should feel about the process of educating teachers in math, science, and engineering in high school, but is there a way to provide a quick fix? I am told that there are a significant and appalling percentage of high schools in the United States that do not even teach chemistry or physics and do not have the physical facilities, much less the imaginative faculty, to begin to ask students to wonder why the sky is Carolina blue.

Dr. GEORGE. And it is bluer in Carolina, probably.

Mr. VALENTINE. Is there something that the National Science Foundation perhaps could be doing if the resources were available to go directly—if a call came in from Jordan High School, not that they would need it, to say, "Well, you go here, and they'll answer you?" Could you give them some help directly, or would that be possible or feasible?

Dr. GEORGE. I would not want to respond as to how the NSF should address that need and I would not want to say that there is any quick fix. But I do think that there are more things that can be done, and I agree with you that the state of education in elementary and secondary schools is not good.

There are elementary schools in this nation, many of them, in which students are not taught how to add fractions because the teacher does not understand how to add fractions and is uncomfortable talking about it. My mind can not cope with that in the greatest nation on earth.

I think that there are ways, in terms of training and retraining existing teachers, of linking technology—high schools and elementary schools even with colleges and universities—there are things that can be done.

One of the keys again—I keep going back to the role of the Federal Government in leveraging other agencies, and I think one of the great areas that something could be done about is in the influencing of school boards and PTAs. One of the most exciting programs to come out of the NSF potentially is their States' initiatives program, in which States are asked to think as a whole about the problems of science education and to propose programs in which all sorts of local agencies and resources can be leveraged.

I am not sure, Mr. Valentine, whether the answer is to have grants programs to individual high schools, recognizing how many high schools there are, or whether the way to get at this is to get at State departments of education, school boards and PTAs, and leverage them with incentives and program support in that way.

Mr. VALENTINE. Thank you. I did not mean to suggest by a quick fix that it was something that should be turned on and then turned off. I am thinking more about what I regard as tragic inactivity of some people with different responsibilities in different areas closer to the problem and a way that we could avoid losing another generation.

Dr. GEORGE. I agree.

Mr. VALENTINE. I think that we ought to try to find a way to meet the needs that we have talked about here today; to find an effective way to use the collective national genius to penetrate some of these areas where there does not seem to be sufficient local initiative.

Dr. GEORGE. The segment of the bill on the educator award system could have a modest impact on that if the awards are chosen and selected for those who are dealing with the kinds of issues that you raise right now. It would not be a quick fix, but it would be a start.

Mr. **Valentine**. I am advised that our colleague Tim Penny has arrived.

Mr. **Penny**. I moved on you, Mr. Chairman. When you first saw me come in, I was sitting in the audience, but I snuck up to the committee table.

Mr. **Valentine**. Welcome. This will be ex post facto. [Laughter.]

Mr. **Penny**. Thank you, Mr. Chairman. I had a press conference which took me away from your committee room for a few minutes. I appreciate your allowing me this opportunity to say a few kind words about my friend, Dr. George.

Dr. George has a sterling academic career. It includes 25 years in major public research universities as a teacher and an administrator. He served as Associate Dean for Science at the Graduate School of the University of Missouri-Columbia, as Dean of the College of Arts and Sciences at the University of Nebraska, and then as Vice President for Academic Affairs of the four-campus University of Missouri system.

Dr. George is a member of the Advisory Committee for the Science and Engineering Education Directorate at the National Science Foundation. He has a lifelong commitment to and involvement in science and mathematics education. As you know, he is the President of St. Olaf College, one of the Nation's premier undergraduate institutions for science and mathematics.

I am proud to have that campus in my district and proud of the work that Dr. George has done as the leader of that school. Again, it is my great pleasure and personal honor to present my friend, Dr. George, to the committee, and we thank him for the excellent testimony that he has presented on this issue.

Thank you.

Dr. **George**. Thank you.

Mr. **Valentine**. Mr. Buechner?

Mr. **Buechner**. I want to join with my colleague, Mr. Penny, in welcoming Dr. George, who served my State of Missouri for many years in such a fine capacity.

Dr. George, what would be a reasonable level of support for these teaching awards, and would this just be an award, or would you think that it should have a specific purpose?

Dr. **George**. I think that purpose as stated is a very good one. I suggested in my written testimony that the level of the award ought to be increased somewhat. I think that three months is not long enough.

My major point is that the awards ought to be tied to institutional criteria so that the institution has to buy in to this, make some commitments to it, and, I hope, be affected by it. I see this as potentially very valuable if the criteria includes some institutional commitments that you can use then to leverage the kind of changes needed.

I think it was Mr. Brown who very correctly said that the problems are in the hiring, the determination of salaries, and the promotions of people on the basis of teaching. So you need to get at the institutional structures through this as well as recognizing individuals.

Mr. Buechner. Put on your institutional hat for a moment. Are we going to have problems with the colleges and universities with us establishing the institutional criteria? Are we going to have one of those reactive elements that will say, "Who the hell are you to tell us what are the proper criteria for turning out good teachers in these areas?"

Dr. George. I would not suggest that you tell them what the proper criteria for turning out good teachers are, but I do suggest that if you are going to give money through an institution to recognize good teaching then you have every right to ask the institution what it is doing to recognize good teaching, what it is doing to see that good teaching is part of the reward structure, and what it will do to see that this person it has nominated actually has the opportunity to spend your money, our money, my money, to influence science education at the institution.

One of the great features of the bill as it is written is that part of the money is for curricular innovations at that home institution. I think it is fair for you to ask the institution to issue some sort of guarantee or statement of commitment with the proposal that they will actually make it possible for that to happen.

I do not see that as unwanted interference. I think that an institution need not apply for this if it feels it is being unfairly intruded upon. I think that what the proper role of the Federal Government is to provide the prods, nudges, and incentives to move this nation in the right direction.

One member of the committee pointed out earlier today that many of our present problems and the great stress upon research to the exclusion of teaching—and I am not arguing for teaching at the exclusion of research. I am very committed to both. I have done both in my life and I think they go together. But a lot of where we are today was occasioned by Federal programs to support research. In many ways, that kind of initiative created the ethos in the large universities we now have, so I do not think it inappropriate at all for you to try to move the pendulum back a little bit.

Mr. Buechner. Just a couple editorial comments of my own—when our chairman here pointed out the lack of some schools having any chemistry or physics programs or advanced math programs—I guess that one of the things that bothers me is that the teachers that these programs will create will probably end up not going to those schools anyway. They will be attracted to the school districts that have wanted to have good programs.

When you go to the inner cities, for instance, where the question is not whether or not they are going to get an education—it is whether or not they are going to live through the day or whether there are going to be drugs sold in your classroom or outside on the playground. It is imperative that we provide that assistance for school districts to provide a safe and healthy environment.

The same thing applies to the homes that they go home to and the streets that they play on or walk on before we can ever achieve anything at this level. With that, I yield back.

Mr. Valentine. Thank you, sir.

Mr. Brown?

Mr. Brown. Thank you, Mr. Chairman.

Gentlemen, I find both of your testimonies to be extremely valuable and helpful. Your emphasis, Dr. Glassick, on broadening the concept of scholarship is exactly what we need in the system today. It is too bad that there are not enough people reading your Carnegie Foundation reports on this.

Dr. George, your suggestions, of course, are totally in the spirit of the legislation. Your statement that we do not go far enough in the emphasis on undergraduate science education, I think, is absolutely true. The proposal for recognizing an excellent science educator is a very, very modest step that needs to be considerably enhanced. Yet, you were here to perceive the reaction of Mr. Bloch to any effort to assist him in improving the program over there.

This is the problem that really faces us. I know that the NSF is trying to do a good job, and we are trying to do a good job in encouraging them and helping them. This bill represents merely a small step in that effort. We think that there is a role for us in Congress sometimes.

Dr. GEORGE. We science educators agree.

I think that Mr. Bloch has done an awful lot, and I have a lot of respect for many of the things he has done. There are a lot of pressures and competing demands on him. I think that the Congress has very clearly helped him get to where he is today, and I hope will help him get even farther.

Mr. BROWN. I am not belittling the delicate nature of this relationship between the Congress and the Executive Branch. I am constantly striving to be sensitive to that and to operate in the most effective way, but it is frustrating sometimes. I know that he is frustrated and I know that we are frustrated. And we hope that something constructive will come about out of that.

There has been some discussion about the inadequacies of science teaching and so forth at lower levels, which is true. This gives me an opportunity to recount my recent visit to Japan where we saw science laboratories in the elementary schools, not just the high schools. There must be some connection between that and the increasing number of Japanese engineers and scientists that are being turned out.

We see good science experiments being developed by high school students in this country and being recognized by programs like the Westinghouse program and NASA's Seeds in Space program at the elementary school level. Now, those elementary school kids may not produce outstanding research results, but they are going to generate an awful lot of enthusiasm for the scientific process. They are going to understand what it means to do research.

That is the kind of thing that we are trying to encourage and to encourage science teachers to appreciate so that that spirit will penetrate throughout the system. I hope that this legislation can be a step in that direction.

I appreciate your suggestions. If I can arrange it, we will call this the Presidential Science Teacher Award and we will increase the length of it. We will copy the Administration in every way that we can. Obviously, we don't want to fight with them over this because we agree with the Administration in most respects here.

Mr. Chairman, I recognize that the bells are calling for us and I will not belabor this further.

Mr. **Valentine**. Thank you, Mr. Brown.

Mr. Skaggs?

Mr. **Skaggs**. Thank you, Mr. Chairman. I will be very brief with just one question as soon as the sound effects cease here.

I am interested—and I apologize for not being here for your remarks earlier—one thing that got my attention a few weeks back, when we heard the announcements that the Administration was establishing goals of being first in science and math by the end of the century in the hearings we held shortly thereafter, was the seeming absence of what the building blocks are for a program that gets us from where we are to achieving that goal. I would appreciate it if you could each address yourselves briefly to whether you see any good construction of building blocks having occurred in the intervening few weeks and how we ought to proceed to encourage them.

Dr. **Glassick**. Well, it is a very difficult area. The tools are in place. One thing we need in our country is greater equity in funding of our school systems.

Mr. Brown talked about some elementary school students who are involved in science and devising experiments and becoming excited about it. Mr. Valentine and Mr. Buechner both talked about some areas where there is no science at all taught in the schools. We can not afford to simply put aside and not teach science to a portion of our young people.

The equity in funding which has just recently been enacted in New Jersey just the day before yesterday—the Supreme Court found it necessary for the State to reallocate its funds in order to bring a greater evenness in education. Of course then, also, there is the preparation of the teachers and the incorporation of additional minority teachers into the system and teachers willing to teach in the inner city.

The answer to your question though is, no, I have seen very few building blocks put in place in recent times except for the court decisions requiring equity.

Mr. **Skaggs**. If I could interrupt and then hear from Dr. George, what I am really looking for is: is there a nascent strategy being put together within the Department of Education and NSF and related agencies that lays out how we will accomplish that goal?

Dr. **George**. Mr. Skaggs, I am more familiar with the NSF. I sit on the Science and Engineering Education Advisory Committee which meets Monday and Tuesday. I am not as familiar with the Department of Education.

I think recent efforts—and I would have to say, no, I do not see those building blocks in place, and that disturbs me. I think that Mr. Bloch talked earlier about the need for developing a strategic plan. If by that he meant a set of building blocks that says these are the things that need to be done in this priority order and these are the agencies that need to do it, then I don't see that in place.

I think it is terribly critical that we have interagency development of such a plan. Part of our problem is that education efforts are fragmented. That is the way it is, and that is the way it is going to be.

In science education, the National Science Foundation has a clear role of significant leadership, but the Department of Education is also a significant player as are the Department of Energy and other Federal agencies. I think attempts like the FCCSET committee to begin to pull together what the Federal Government's sense of priorities might be for this is a very important first step.

However, I think that we have an awful lot of individual programs in a whole lot of agencies that sort of float in isolation in no context. And I think that a hearing like this, which can be a little wide ranging, is an awfully important set of things for you to do, to have an opportunity to ask: is there anything we can do without waiting for the next generation of teachers?

I hear your yearning and I share it. I have only been at one meeting of the SEE Advisory Committee. This week coming up will be my second. But that is the main theme that I intend to play. Where is the plan, and where are we in the development of a plan, and where are we in bringing all Federal agencies and all interested parties and professional societies and museums together to say, "Let's quit talking about 4,000 individual programs and get on with it."

Mr. SKAGGS. I appreciate your comments. We do have to run out and vote, but I do want to emphasize that it is, I think, unfortunate if we have established a goal without having as a preceding matter at least gotten a sense of the practicability of the goal because that is setting us up to be disappointed in ourselves, which we certainly do not need.

Thank you, and thank you, Mr. Chairman.

Mr. VALENTINE. Thank you.

I want to say again to you gentlemen, this committee and all of us thank you officially and personally for being here and sharing these words of wisdom with us. We thank you for what you have done and what you will do for our country.

I believe that you believe, and I think that most of my colleagues in the Congress believe, that unless we are able to get a handle on this problem, unless we are able to provide better educational opportunities for every race and every region in this country, we are going to find ourselves, before your children get my age, on a decline that has accelerated to the extent that we will never recover. We thank you for this.

I will go vote now and we will come back shortly.

Dr. GEORGE. Thank you, sir.

[Recess.]

Mr. VALENTINE. I don't think I need the gavel. While we are assembling, I need to offer apologies to the third panel because the crowd seems to dwindle. While we are stalling for just a second to see if other Members do show up, I must share with those present what I just heard, a comment from a Member as we went over to vote.

He said that when Marx and Engels got started with communism, they thought that if they took all of the money out of the system that people would not exploit other people, but they found out pretty soon that people would exploit other people just for the hell of it. [Laughter.]

This panel consists of Dr. Phillip R. Certain, Professor of Chemistry, University of Wisconsin-Madison, Dr. Gordon Nelson, Dean, College of Science and Liberal Arts, Florida Institute of Technology, and Dr. Homer A. Neal, Chairman, Department of Physics, University of Michigan.

Dr. Neal has a demonstrated need to go first as I understand it because his airplane might leave before he does.

Dr. Neal?

STATEMENT OF DR. HOMER A. NEAL, CHAIRMAN, DEPARTMENT OF PHYSICS, UNIVERSITY OF MICHIGAN, ANN ARBOR, MI

Dr. **NEAL**. Thank you very much.

Mr. Chairman and Members of the Subcommittee, I am honored by your invitation to appear before you today to discuss my views on the draft legislation for the Science and Technology Act of 1990.

As a member of the National Science Board in 1985, I chaired a committee to examine the health of undergraduate science, mathematics, and engineering education in the United States. In that report, a copy of which has been submitted for the record, we noted that serious problems, especially problems of quality, have developed during the past decades in the infrastructure of college level education in the United States.

Our committee concluded that the National Science Foundation should take a strong leadership role in a nationwide effort to address the problems identified. Furthermore and especially germane to the issues under consideration here today, we recommended that the National Science Foundation should stimulate creative and productive activities in teaching and learning just as it does in disciplinary research.

The invitation extended to me by the committee requested that I specifically look at Section 6 of the draft bill. I find that this bill has many virtues. There can be no doubt that the problems which exist in undergraduate education in this country are so massive that they cannot be remedied by any simple action taken at the Federal level.

However, carefully developed Federal initiatives can be very important in stimulating local action and creativity. This initiative seems to be designed to do this precisely.

It highlights the importance of high quality instruction at the undergraduate level. It supports the concept that university faculty should be outstanding teachers and outstanding researchers. It takes into account the benefits that will be derived from local competition and the review of exemplary science educators within individual universities. It notes the value of national recognition being given for outstanding teaching, and it also provides direct financial support for the advancement of science education and research. Though the allocation of funds required for such a program would be modest, the overall impact could be very significant.

There are a few detailed issues associated with the specific language of the bill that I would like to call to your attention. For example, it is not clear to me why the criteria for selection of awardees includes reference to the "potential of the applicant to maintain continued professional growth through a limited but ongoing program of research or other scholarly activity." My concern is not about the concept of continued research, but about the word "limited."

It is important that Congress not fall into the trap of assuming that a faculty member can not be both an active researcher and a talented and dedicated teacher. Thus, I would urge that special care be given to the statement of this criteria.

I also have cautionary comments to make concerning the sentence in the bill that states that "each award under the program shall be for a three year period, and shall be made on the basis on nominations submitted by academic institutions on behalf of science faculty members who commit a significant part of their careers to undergraduate scientific education." The question arises as to what is meant by the term "a significant part of their careers."

There is the vague implication that one would have to invest numerous years in science education before he or she could qualify for this new program. While the purpose of such a restriction might have some justification, there is also the danger of this provision excluding bright and dedicated young faculty members. It is very important that actions not be taken by Congress that would agree with the commonly held belief that young faculty members should steer clear of any expression of special interest in undergraduate education.

I would also note a provision of the bill that would restrict the number of awards to any given institution to a maximum of one. Clearly, there are numerous administrative benefits to being able to limit the nominations to one per institution. However, this stipulation does introduce disparities in the probability that an outstanding faculty member at a large institution would be recognized, in comparison to the corresponding probability for an outstanding faculty member at a small institution.

We must not forget that there are some science departments at large institutions that have as many faculty members as there are faculty members in an entire small university. We must ask the question: is it institutions we are trying to recognize and reward, or is it outstanding faculty members?

It cannot be overemphasized that one of the limiting constraints on achievement by faculty is the availability of time. In the course of a day, many faculty engaged in undergraduate education at a research university must teach large courses, meet with students, meet with graduate assistants in charge of handling recitation sections, write letters of recommendation for their present students and past students, sit on departmental committees, university committees, national committees, testify before Congress, and at the same time, attempt to sustain their own research programs. Very little time is left to consider innovations in teaching, planning for future courses, assessing the needs of instructional laboratories, and so on.

For an award program of the type being considered to be successful, it is very important that provisions are included to afford the faculty member an opportunity to become deeply involved in his or her planned science education initiatives. I am pleased to note that a total of three months of salary support is provided for in the bill. I would only suggest that this amount might be augmented by at least a corresponding amount of release time by the university. Stated differently, I would not want to see a recipient of this award spend the entire three year period of the award simultaneously being assigned arduous teaching or other responsibilities while trying to do an exceptional job of executing the program laid out in his or her proposal.

There is often a temptation on the part of departments to rely heavily and almost exclusively for the large course on one or two individuals who are known to be outstanding teachers. These, of course, are precisely the individuals that we would expect to be successful in the competition. Many departments might simply ask a successful educator award winner to take on the additional responsibilities of the grant as an overload. Without some protection, the needed time to successfully carry out the plans detailed in the applicant's proposal just may not be available.

The remarks here are intended to ensure that the final language of the bill receives the type of scrutiny such an important piece of legislation deserves. I hope that they are taken in that context. It is important that I emphasize, however, that I believe that the general initiative is outstanding and that it is highly consistent with the views expressed by our earlier task committee of the National Science Board.

Mr. Chairman, I would like to conclude by making a couple of general comments. Developments at the National Science Foundation last week, in which other modalities of administering science education were reportedly seriously considered for adoption, lead me to make the following comments.

The NSF must be very careful not to distribute oversight of the undergraduate programs so thinly throughout the Foundation that the programs become invisible and subject to local neglect and/or abuse. Research and science education are indeed closely related. But as science education struggles to achieve a proportionate level of funding comparable to that it had decades ago, and in the horrendous environment which presently exists that shamefully limits funding for single investigator research projects at the Foundation, now is not the time to permit the matter of priorities to be established individually at the disciplinary level.

I am expressing my personal preference that there remain a strong science and engineering education directorate within the National Science Foundation, and that this directorate continue to have primary oversight for all undergraduate science, engineering, and mathematics education activities. The fact that disruptive tensions exist between science education and research is yet one more indication of the critical need for overall increased support for the NSF.

Finally, given the precipitous and mysterious change in the directorship of the science and engineering education unit at the NSF last week, I am moved to make the following comments. I can not let this opportunity pass without commending Dr. Bassam Shakhashiri for his strong leadership and dedicated service to the NSF and to the Nation.

He has brought the SEE directorate from the ashes of 1983 to an entity that now has a set of very effective programs. We all owe him a debt of gratitude, and his successors will bear a tremendous burden of responsibility to see that his visions are indeed achieved.

Mr. Chairman, thank you again for inviting me to meet with you today.

[The prepared statement of Dr. Neal follows:]

TESTIMONY PRESENTED TO THE U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY:

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

HEARINGS ON THE SCIENCE AND TECHNOLOGY
EDUCATION ACT OF 1990

Homer A. Neal
Chairman, Department of Physics
University of Michigan
Ann Arbor, Michigan
June 7, 1990

Neal, 47, is Chairman of the Department of Physics at the University of Michigan. He served as Dean of Research and Graduate Development at Indiana University from 1976 to 1980 and as Provost of the State University of New York at Stony Brook from 1981 to 1986.

In 1979, he was appointed by President Carter to a six year term on the National Science Board, the governing body of the National Science Foundation. He has served on the Boards of Trustees of Argonne National Laboratory, the Fermi National Accelerator Laboratory and the Scientists Institute for Public Information, and is a Director of the Ogden Corporation. He has served as Chairman of the National Science Foundation Physics Advisory Committee, and is presently on the Board of Overseers for the Superconducting Super Collider and a member to the governing board of the Smithsonian Institution.

Neal is a graduate of Indiana University (bachelor's degree, 1961) and of the University of Michigan, where he earned a doctorate in physics in 1966. He conducts research in elementary particle physics, focusing on experiments at very high energy accelerators. He is a Fellow of the American Physical Society and the American Association for the Advancement of Science. He has also been a Fellow of the John Simon Guggenheim Foundation and the Alfred P. Sloan Foundation.

I am honored by your invitation to appear before the Subcommittee on Science, Research and Technology today to share my views on the draft legislation for the Science and Technology Education Act of 1990.

As a member of the National Science Board in 1985, I chaired a committee to examine the health of undergraduate science, mathematics and engineering education in the U.S. In that report, a copy of which is being submitted for the record, we noted that "serious problems, especially problems of quality, have developed during the past decade in the infrastructure of college level education in the United States in mathematics, engineering, and the sciences." Our committee concluded that the National Science Foundation should take a strong leadership role in a nationwide effort to address the problems identified. Furthermore, and particularly germane to the issue under consideration today, we recommended that "the National Science Foundation should stimulate creative and productive activities in teaching and learning ... just as it does in basic disciplinary research."

Over the years since this report the Foundation has expanded its activities in undergraduate education from essentially zero to a varied and effective program having a nationwide impact. Programs such as the research experience for undergraduates, the undergraduate curriculum programs in calculus and engineering, and the instrumentation program are all examples of activities launched in recent years that are well on their way toward meeting national needs. But there is much more to be done.

The invitation extended to me by the subcommittee requested that I specifically address Section 6 of the draft bill. This section pertains to the establishment of a NSF award program for faculty who excel in undergraduate instruction in science, engineering and mathematics. I find that this bill has many virtues. There can be no doubt that the problems which exist in undergraduate education in this country are so massive that they cannot be remedied by any simple action taken at the federal level. However, carefully developed federal initiatives can be tremendously important in stimulating local action and creativity. This initiative seems designed to do precisely this. It highlights the importance of high quality instruction at the undergraduate level, it supports the concept that university faculty should be both outstanding teachers and outstanding researchers, it takes into account the benefits that will be derived from local competition and the review of exemplary science educators within individual universities, it notes the value of national recognition being given for outstanding teaching, and it also provides direct financial support for the advancement of science education and research.

Though the allocation of funds for such a program would be modest, the overall impact could be enormous.

There are a few detailed issues associated with the specific language of the bill that I would like to call to your attention. It is not clear to me why the criteria for selection of awardees include reference to the "potential ...of the applicant to maintain continued professional growth through a limited but ongoing program of research or other scholarly activity". My concern is not about the concept of continued research, but about the word "limited". It is important that Congress not fall into the trap of assuming that a faculty member cannot be both an active researcher and a talented and dedicated teacher. Thus, I would urge that special care be given to the statement of this criterion.

I also have cautionary comments to make concerning the sentence in the bill that states that "each award under the program shall be for a three year period, and shall be made on the basis of nominations submitted by academic institutions on behalf of science faculty members who commit a significant part of their careers to undergraduate scientific education". The question arises as to what is meant by the term "a significant part of their careers". There is the vague implication that one would have had to invest numerous years in science education before he or she could qualify for this new program. While the purpose of such a restriction might have some justification, there is also the danger of this provision excluding bright and dedicated young faculty members. As noted in an attached paper, which formed the basis for a talk I recently delivered at a conference on the "Freshman Year in the Sciences," sponsored by the Undergraduate Alliance, it is extremely important that we do all we can to interest young faculty in undergraduate science education. It is important that actions not be taken by the Congress that would reinforce the commonly held belief that young faculty members should steer clear of any expression of special interest in undergraduate instruction.

I would also like to note the provisions of the bill that would restrict the number of awards to any given institution to a maximum of one. Clearly, there are numerous administrative benefits to being able to limit the nominations to one per institution. However, This stipulation introduces enormous disparities in the probability that an outstanding faculty member at a large institution would be recognized, in comparison to the corresponding probability for an outstanding faculty member at a small institution. We must not forget that there are some science departments at large institutions that have as many faculty as there are faculty in an entire small university. We must ask the question, "Is it institutions we are trying to recognize and reward or is it outstanding faculty members?".

It cannot be overemphasized that one of the limiting constraints on achievement by faculty is the availability of time. In the course of a day, many faculty engaged in undergraduate education at a research university must teach large courses, meet with students, meet with graduate assistants in charge of handling recitation sections in these courses, write letters of recommendation for their present students and for previous students, sit on departmental committees, university committees, national committees, testify before Congress, and at the same time attempt to sustain their own research programs. Very little time is left to consider innovations in teaching, planning for future courses, assessing the needs of instructional laboratories, and so on. For an award program of the type being considered to be successful, it is very important that provisions are included to afford the faculty member an opportunity to become deeply involved in his or her planned science education initiatives. I am pleased to note that a total of 3 months of salary support is provided for in the bill. I would only suggest that this amount be augmented by at least a corresponding amount of released time by the university. Stated differently, I would not want to see a recipient of this award spend the entire three-year period of the award simultaneously being assigned arduous teaching (or other) responsibilities while trying to do an exceptional job of executing the program laid out in his or her proposal. There is often a temptation on the part of departments to rely heavily, and almost exclusively for the huge lecture courses, on the one or two individuals who are known to be outstanding teachers. Many departments would simply ask a successful "Educator" award winner to take on the additional responsibilities of the grant as an overload. Without some protection, the needed time to successfully carry out the plans detailed in the applicants proposal just may not be available.

The remarks above are intended to insure that the final language of the bill receives the type of scrutiny such an important piece of legislation deserves, and I hope that my comments will be useful in this context. It is important that I emphasize, however, that I believe this general initiative is outstanding, and that it is highly consistent with the views expressed by our earlier task committee of the National Science Board.

Developments at the National Science Foundation last week, in which other modalities of administering science education were reportedly seriously considered for adoption, lead me to make the following comments. The NSF must be very careful not to distribute oversight of the undergraduate programs so thinly throughout the Foundation that the programs become invisible and subject to local neglect and/or abuse. Research and science education are indeed closely related. But as science education struggles to achieve a proportionate level of funding comparable to that it had decades ago, and in the horrendous environment which presently exists that shamefully limits funding for single investigator research projects in the Foundation, now is not the time to permit the matter of priorities to be established individually at the disciplinary level. Thus, I am expressing my personal preference that there remain a strong science and engineering education directorate within the National Science Foundation and that this directorate continue to have primary oversight for all undergraduate science, engineering, and mathematics education activities. The fact that disruptive tensions exist between science education and research is yet one more indication of the critical need for overall increased support for the NSF.

In closing, given the precipitious and mysterious change in the directorship of the science and engineering education unit at the NSF last week, I am moved to make the following comments. I can not let this opportunity pass without commending Dr. Bassam Shakhashiri for his strong leadership and dedicated service to the NSF and to the nation. He has brought the SEE Directorate from the ashes of 1983 to an entity that now has a set of very effective programs. We all owe him a debt of gratitude, and his successors will bear a tremendous burden of responsibility to see that his visions are indeed achieved.

Mr. Chairman, I wish again to thank you and members of the subcommittee for inviting me to meet with you today.

THE FRESHMAN YEAR

IN THE SCIENCES:

HOW IMPORTANT ARE

FACULTY INCENTIVES?

by

Homer A. Neal

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Ann Arbor, Michigan

April 6, 1990

INTRODUCTION:

I am honored to have been asked to participate in today's conference on "The Freshman Year", and I want to congratulate the conference organizers for taking the initiative in highlighting the importance of the introductory science courses.

My presentation will not focus on teaching techniques, curricular changes, or such matters, for I am sure that there are many here far better equipped than I to deal with these central issues. Rather, I would like to take this opportunity to examine the delicate topic of faculty incentives and make some other observations from the point of view of a departmental and university administrator. Also, I want to share with you some of the views of numerous faculty, university administrators, industrialists and government officials that were expressed during a study on undergraduate science and engineering education I chaired a few years ago for the National Science Board.

In adopting this somewhat narrow perspective, I will be relying on the panelists to raise and address issues that are necessary to fill in the broader picture.

IS THERE A PROBLEM?

Almost by definition, very few activities with sentimental value seem as perfect today as they were in yesteryears. Going to the airport on a

Sunday afternoon to watch the planes take off and land used to be fun. Nowadays, that is the last place most of us would want to get near. Have the airports failed us? Not necessarily - our accumulated experience has shaped our view of them. What caught our imagination in the past may now be viewed as routine -- and we have no difficulty in generating a long list of criticisms of entities with which we have become familiar.

Is the same true for undergraduate education at our nation's colleges and universities? Has our success of infusing tremendous amounts of information into eager bright undergraduates in past decades given way to contempt for the process with which we have become all too familiar?

As scientists we must be careful not to let nostalgia cloud our assessment of the present. But, with this caution firmly in view, I personally believe there are solid reasons for concluding that we are indeed in the midst of a crisis in undergraduate science education. Moreover, whether or not some of our present concerns are associated with the fact that undergraduate science education does not seem as thorough and effective as it used to be, what is perhaps more germane is whether our educational institutions are up to the tasks demanded by the coming century.

Let me list some of the reasons for concern that they may not be:

- Comparative performance of U. S. students on standardized science tests show that the level of training of our students is behind that of most industrialized countries. Given the obvious connection between economic progress and technological advancement, this is clearly cause for concern.

- The coming century will clearly be one in which information technology will be a dominant driving force. In spite of this, we have remarkably few students majoring in science at U.S. institutions of higher education, and present trends offer no encouragement.

- As a result of simple demographics, we can expect the overall number of school age children to decline over the next decade -- and the decline in those population groups that have traditionally been the source of most of our scientists and engineers will be the most precipitious.

- There is a tremendous difference in the number of qualified students entering college wishing to major in the sciences and the number of students who indeed finish college with a degree in the sciences.

- According to data from the National Science Foundation, if the current trends are allowed to continue, by the end of this century we will be graduating 100,000 fewer students per year with B.S. degrees in science and engineering than we were in 1984.

Many of these concerns are encapsulated in the following statement from a Department of Energy study in July, 1988:

"The U.S. is faced with a decline in the quality and quantity of students preparing for careers in science and engineering."

Independent of national needs associated with securing an economic competitive advantage, there is another important reason why we should be concerned by the present level of science literacy. One of the fundamental underpinnings of our democracy is the premise of a broadly knowledgeable populace. If "we the people" are to make the policy decisions about the directions of the country, it is important that those decisions be made on the basis of knowledge, rather than through ignorance and superstition.

Having a large fraction of the population being scientifically illiterate is a cause for concern. Many Americans have almost no grasp of the fundamentals of physics, astronomy, chemistry, biology, or, for that matter, mathematics. And what they think they know about these fields is often wrong. Moreover, for many there is little embarrassment that they know so little. Indeed, in some circles, it is even a mark of distinction to portray contempt for these fields.

There is also the problem of whether we will have the ability to replace retiring faculty -- given the fact that a large fraction of the present science and engineering faculty in the U.S. will retire in the 1990's. Typically, faculty come from a pool of students regarded as the "best and brightest" during their high school and undergraduate years. Thus, it is of interest to look at the rate at which the very highest scoring students are choosing a career in the sciences (and in this context I am specifically referring to the physical sciences and not engineering or mathematics -- though elsewhere the term sciences has been used to include all). A few years ago I chaired a small committee for the Universit Government Industry Roundtable established to take a preliminary look into this matter. The data we had available suggested an especially sharp decline in the number of highly talented young people choosing careers in the physical sciences. Many were choosing business, engineering, and other areas where lifetime earning projections were more favorable. This raises troubling concerns for the future.

I believe there is no doubt that we have a real problem in undergraduate education, and that we have only a limited time to begin to address it on the appropriate scale before there is a serious impact on the well-being of our country.

WHAT ARE THE CAUSES OF THE PRESENT SITUATION:

As we found in our National Science Board study, there are many contributing factors to the present situation in undergraduate science education. The nation has just come through several decades that saw mushrooming pressures being placed on our universities to educate more and more students while also becoming more and more competitive in research. These pressures have had a significant effect on undergraduate education. Indeed, after describing many of the factors which have shaped the present relations between universities and the federal government, a recent report from the Government Roundtable commented: " With regard to undergraduate education, all of these factors combine to provide disincentives to teaching. The increasing scale of organizational complexity of much new academic research activity, a faculty salary system that increasingly rewards research accomplishments, and federal policies which favor research over educational programs further exacerbates the situation."

The defects in undergraduate science education are often characterized as follows: The faculty seem less interested in undergraduate science teaching than they used to be. Researchers try to avoid it as much as possible. Dedicated teachers are overworked and are undervalued in their departments. Resource decisions almost always go in the direction of enhancing a department's research reputation. Fewer faculty are taking the time to write innovative and up-to-date texts. Class sizes remain large, and few students have the actual opportunity to work in small settings with faculty. Laboratory instrumentation is out-of-date, resulting in student frustration And many faculty feel that students are not well prepared or interested in any aspect of their courses beyond their grades.

While these criticisms may be valid in many instances, such a broadside ignores the fine work being done at many places by many faculty. But problems clearly exist. To arrive at the precise areas requiring improvement, one should look at what we wish for the students to learn while in college, what the variables are that determine the outcome, assess whether the variables are optimally tuned, and then determine what needs to be done to adjust the variables accordingly. For example, if faculty morale is an important issue affecting the quality of undergraduate education, then find out why the morale is low and fix it.

Factors that determine the overall effectiveness of the educational process include:

- the student's level of preparation

- the college curriculum
- effectiveness of the instructors
- quality of the instructional tools
- out-of-class student learning opportunities

To do a thorough job of analyzing just how well universities are performing in training young people in science, one would have to look carefully at each of the factors -- and their interrelations. Indeed, this is how we attempted to structure our work in the publication NSB- # 1986-100 on the state of Undergraduate Science and Engineering Education in the U.S. We can not make such a broad review in the time we have available today; rather, I would here like to concentrate on the one issue of faculty effectiveness -- and in particular, faculty motivation.

Before going immediately to this topic, however, I do want to congratulate the NSF SEE Directorate for moving forward on all of the fronts represented by the list above. The ultimate success of getting more students to become interested in science and to successfully enter the S/T workforce requires that each of the above factors operate to encourage the students progress all along the way.

IS IT PROFESSIONALLY RESPECTABLE AND WISE FOR FACULTY TO TEACH THE INTRODUCTORY COURSES?

There is an unfortunate belief among many faculty that their colleagues who desire to teach the large introductory courses are either extraordinarily committed to teaching or are unable to do much else. Moreover, the argument goes, if they are in the former category, they will soon be in the latter. Let us analyze why this unfortunate adage survives.

First, let us set up a model that might characterize a science faculty member who is a good researcher and a good contributing member to a department's teaching and service effort. Assume that this person teaches 1 course per semester, thereby investing 4 contact hours in class each week, and 12 hours outside of class on his or her course. This 16 hours per week of teaching time is then augmented by approximately 6 hours of departmental or university service and attendance at colloquia and seminars. Moreover, the faculty member, because he or she is well recognized in the field gives a seminar or colloquium at other universities twice a month, and that the average trip takes a total of 12 working hours. Now, we are up to a total of 28 hours of measured time out of a week.

There is also the matter of research. The amount of time required to sustain an active research program depends on several factors, including perhaps whether the faculty member is an experimentalist or a theorist. Assume for purposes of this calculation that an average of three hours per work-day is minimally required. This brings the total to 43 hours.

It is important to notice that I was quite careful to not say that a scientist works 40 hour weeks. That is certainly not the case. But there is some finite amount of time that a human can invest in the long term and remain in reasonably good physical and mental health. Whatever that limit is, the difference between that quantity and the 43 hours calculated is the creative time available to a faculty member -- and to many this is the time that either makes him or her a great scientist or a failure. Suppose, for purposes of argument, our chosen faculty member puts in 55 hours a week on academic activities. Then the faculty member would have 12 hours (including nights and weekends) to do whatever he or she wishes to do on initiatives associated with teaching, research or service.

Suppose now, under these circumstances, a departmental chair approaches the above professor and asks him or her to take on the teaching of a large introductory course, and indicates that it will only take an additional incremental hour or two per day beyond that required to teach a smaller upper-level course.

The faculty member then does the mental calculation that reveals that such a responsibility will invade roughly 50% of the available discretionary time.

The thought process then goes to the next step -- that of salary and advancement within the faculty member's department. He or she asks, silently or maybe openly, if doing a good job in this course will result in reward at salary setting time, and will it have a positive impact on promotion prospects.

Unfortunately, the answer at many institutions is that the faculty member chosen for the larger teaching responsibility would be better off gracefully declining the chair's invitation (if that is possible). The additional research that could be accomplished with the protected discretionary time and the incremental research distinction received in his or her field, would all bring benefits that would outweigh any appreciation for the faculty member[illegible]ing on the larger course.

So, what happens? The course has to be taught -- no question about that. The department then often turns to someone who has taught the course before -- perhaps many, many times before. That person, who is clearly an outstanding teacher, has suffered because he or she is on a path from which there appears to be no escape. Their research stature is lower than that of their colleague above, because perhaps they have been deprived for years of the discretionary time that is so important in laying out a research agenda. This lower stature makes them less successful in arguing for a relief -- so that he or she keeps teaching the higher load courses term after term.

In the process, the good teachers become burned out. The students know that. Indeed, their faculty colleagues know that --and these colleagues become even more resolved to not get themselves trapped in this cycle. So they will resist even more vigorously the next time the chair asks them to teach such a course.

What we have is a system with a lot of strong feedback, leading to total degeneration if no effective intervention is made.

As an aside, I want to point out that the differential between small courses and the large introductory courses are probably more dramatic than I have indicated above. Doing a good job in a large course can be a tremendously taxing responsibility. In speaking to one of our own outstanding teachers in the University of Michigan Physics Department, I noted the enormous amount of time she invests in our introductory courses. There is time needed to go over the demonstration experiments -- to make sure that nothing goes wrong. There is the time spent in literally rehearsing the lecture presentation to try to avoid embarrassing and/or confusing snafus before a group of hundreds of students. There are the large number of personnel problems that have to be resolved each day (e.g., student X does not like what teaching assistant Y said in the recitation section last week). There is the extraordinary responsibility for generating fair but probing exams -- sometimes in several versions for different sections of the class, and then there is the grading process. And, if this is not enough, there is the realization that after all of your efforts, a significant number of students will be dissatisfied and critical. Indeed, almost no matter how good a job a faculty member does in the introductory courses, the faculty evaluations will likely average much less than one might expect. A similar teaching effort in a smaller, upper-level class might result in rave reviews.

Can anything be done to change the perception and reality that teaching the introductory courses is to be done with great trepidation? The answer is yes. It is important that departments see to it that teaching the introductory courses is a shared responsibility, and that adequate staffing and other resources are available to make teaching these courses interesting and manageable. The lecture demonstration tasks, grading, test scoring, organization of the teaching assistants, etc. should be efficiently organized. Databases should be established to make it easy for the professor to track progress of the students. I will give additional recommendations later in the discussion.

What about the salary matter? Many departments these days do rank their faculty on the basis of teaching, research and service as part of the annual salary setting process. Indeed, doing this permits departments to respond in the affirmative when asked if they take teaching into account when faculty raises are set. But this is a very complicated process. It is made complicated by the fact that there are only 24 hours in the day. That is, faculty who spend twice as much time as average on their research are more likely to achieve a higher research score than faculty who spend only the average amount of time. And the same goes for teaching. There are limits as to how much one can improve his or her teaching score without depressing their research score. Though the improvement of teaching techniques and course management can help upgrade overall teaching effectiveness without requiring the investment of more time -- for the introductory courses, time and motivation seem to be the dominant determinants.

Therefore, a scatter plot of research score vs. teaching score for a department may have a cluster of high research/low teaching scores, a cluster of low research/high teaching scores, some high research/high teaching scores, and, unfortunately, some low research/low teaching scores. The clusters containing high research/low teaching and low research/high teaching scores seems to basically reflect the result of individuals of strong intellectual abilities simply choosing how they wish to invest their intellectual energies. They seem to have a commitment and ability to do well on whatever they have chosen to be their primary professional priority.

The cluster containing faculty who do poorly both in teaching and research often have some underlying difficulty which can be addressed through the long-term personal intervention of a chair or other administrator. Some may represent poor tenure decisions made by the department. Others may have become disaffected with academe as a result of the loss of research support, internal departmental politics, etc. It is very important that such faculty not be abandoned. They represent a vital departmental resource, and can be regenerated to become effective contributors, in many cases.

Now, of course, I must also explicitly mention the class of faculty who excel both in teaching and research. They are the ideal -- and the ideal does truly exist. But, in a typical department at a large research university, the number may be small. These individuals, either through their sheer intellectual ability, or their administrative ability to balance a number of competing demands, can perform outstandingly well in the classroom while keeping a vibrant research program on course.

Every department should aspire to recruit as many faculty as possible that are outstanding in both teaching and research. But, it is also important that it is realized that a department will, for historical or other reasons, naturally be composed of individuals with a spectrum of skills and talents, and that it can nevertheless be very effective, providing that departmental resources are deployed in a way that maximizes the impact of each individual.

To return to the question of salary, then, in an environment where average salary raises are in the neighborhood of 5%, it is very difficult to convince a faculty member that the improvement in their teaching score as a result of putting more effort into, for example, a "Freshman Year" course, will outweigh any reduction in their research score that might occur as a natural result of time saturation. This is a real issue in the area of faculty incentives.

WHO SHOULD FIX THE PROBLEM?:

In short, to fix the problem will require the efforts of all of the controlling parties. At the input end, the local school systems, with assistance from the NSF and Department of Education, must repair the matter of student preparation and interest in science. Of course, there will also be a major role for colleges and universities to play in addressing these issues -- but the primary responsibility will rest at the local level.

At the undergraduate level, the motivation for change should come from the faculties, who in turn should make known their needs to the administration and to the federal agencies.

A cultural change must occur, where undergraduate teaching is viewed on a par with other departmental activities. The responsibilities for the freshmen year courses need to be shared so that they do not become burdensome to any one individual. Extraordinary teaching success should be rewarded in special ways, perhaps using funds set aside specifically for this purpose.

An interesting analysis of how decisionmaking in a departmental setting can result in teaching ending up on the short end was given by Crecine during his testimony before our NSB Committee on Undergraduate Science and Engineering Education. He noted that what gets done in such an environment is normally that matter which is high on everyone's agenda, but is absolutely top priority for one or more individuals who enjoy the respect of the group. In a setting where research related items are on the top of everyone's list, it will only be infrequently that some teaching related item (which may be as high as #2 on everybody's list) will ever get taken care of, especially when resources are tight and tradeoffs have to be made.

It is precisely for this reason that strong leadership from the university administration is required. Somehow departments have to be shown that it is in their best interest to pay careful attention to instructional matters, through the reward and withholding mechanisms available to the university.

It is incumbent upon departmental faculty to state clearly what they need for instrumenting the undergraduate laboratories, for lecture demonstration equipment, and so on, and for departments to provide released time for certain faculty to prepare grant proposals to have these needs met, either through federal programs or through solicitation of private companies.

Undergraduate Research Participation programs were found by the committee I chaired to be extremely effective in getting students interested in science -- in giving them an opportunity to find out precisely what a real scientist does, and to dream about what life might be like for them 3,5, 10 years from now, if they continued on a career in science. I am pleased that our recommendations for dramatically increasing NSF involvement in this program are being implemented.

WOMEN AND MINORITIES:

No discussion about the future science and engineering human resource needs of the country can possibly be complete without noting that if we are unable to attract a higher fraction of women and minorities to go into the sciences we will have an enormous problem in meeting national needs.

We lose women and minorities in the S/E pipeline all along the way. But there is a significant loss at the "Freshman Year". It is the traumatic introductory courses where many students determine if their dream of becoming a scientist or engineer has any chance of being realized. They hop onto a speeding platform which, if all goes well, will stop at graduation some years later. If they fall off during a turn, they may never get back on.

It is in the freshman year that many female and minority students have to make the most extreme adjustments of their career. Exclusion from study groups, negative signals from the professor or TA regarding how the student is regarded intellectually, the lack of role models to reaffirm the belief that it is indeed possible for non-whites and females to become scientists -- are all obstacles that can serve to dislodge students from the speeding platform.

Thus, any study of the freshmen year should take this matter into account. Recommendations that I would have include special efforts to involve promising young women and minority students in summer research activities prior to the freshman year, and to provide special mentoring or support structures for these students during their freshman and sophomore years.

WHAT UNIVERSITIES SHOULD DO?

It would be great to be able to prepare a list of steps that, when completed, would result in all of the problems of undergraduate science education being solved -- thus permitting us to turn our considerable energies to some other problem. Such is not likely, but that should not keep us from trying.

- Every university should conduct a review of its introductory science curriculum, with an eye toward having smaller classes, more laboratory experiences, pass-fail grades, and an assessment of the state of laboratory equipment
- Every graduating student should be asked to have an exit interview and to

comment on their undergraduate experiences and offer suggestions for improvement. This should be a formal process with some provisions to make sure that each substantive suggestion is given a fair review in the department.

- Each department should be asked to develop a policy for rewarding good teaching, and for providing good teachers with regular opportunities for renewal in their research disciplines. For example, a research leave every three years for someone who teaches the introductory courses would not be unreasonable.

PROGRESS AT THE NSF

I have been asked to say a few words about how I view the progress made at the NSF in the years following our National Science Board study. As is clear from remarks made earlier, I am very impressed by certain strides that have been taken. It is important to keep in mind that in the past decade, and prior to our study, there was essentially no organized undergraduate support program at the NSF. Such programs have now emerged as significant activities within the overall umbrella of NSF responsibilities.

Notable among recent actions taken by the NSF in response to our report is the creation of a Division of Undergraduate Science, Engineering and Mathematics Education. It was inconceivable to us that the NSF could mount an effective leadership of undergraduate activities in the absence of any administrative focal point with specific responsibilities for undergraduate education. The past couple of years have demonstrated the value of such an office, as it has moved vigorously and effectively under the leadership of Bob Watson to crystallize the nation's thinking about undergraduate science education issues -- including, indeed, the sponsorship of this and other conferences and workshops.

Let me mention a few programs of special interest. The undergraduate curriculum programs in calculus and engineering which were established in 1988 seem to be progressing quite well and are already having the desired impact. The instrumentation program for small colleges also appears to be off to a good start, though its counterpart program for universities has had a troubled beginning, which I trust will soon be remedied.

The Career Access for Minorities program has gained considerable momentum, funded at $11.3M in FY1990, and is in the FY91 budget for $15 M. This program should help address many of the issues raised concerning the need to improve the access of minorities into the science and engineering pipeline.

I have already mentioned the value of providing research experiences to undergraduate students. I understand that the REU (research experiences for undergraduates) program is funded this year at about $12 M , with about half of this amount going to supplements to existing grants.

It is important that these programs have an opportunity to mature and to evolve to meet the needs of the country. It is also important that a degree of stability of the NSF science education programs be achieved, so that faculty can make long term plans based on program pronouncements. I was especially pleased by the announcement in December of a new course and curriculum development program to encompass all of the science disciplines. In this context, I was disappointed by the precipitious decision to postpone the proposal deadline. I do not know the details of why at the last moment the deadline was changed but, even though many of my colleagues were relieved to have more time to work on their proposals, there are two reasons why the delay is a source of concern. First is the postponement by yet another fiscal year of an attack on the curriculum development problem. The second reason is the signal that such changes send to the community that statements from the NSF on undergraduate education matters may not be rock solid. This is a challenge that must be overcome, so that senior faculty will not hesitate to make career decisions to invest their energies into helping with the resolution of the various undergraduate science education issues.

These NSF initiatives to date are to be commended -- and we clearly owe a debt of gratitude to Bassam Shakhashiri for his tireless efforts. Erich Bloch and the NSF staff will need our continued support, urging and encouragement as they attempt to address these human resource issues in an environment of constrained resources. It had long been my hope that the process of doubling the NSF budget would provide an ideal framework for addressing the undergraduate science and engineering education needs, while simultaneously taking care to meet the many research support needs facing the country. That the "doubling-program" has taken longer to get underway than expected has undoubtedly complicated the process. But the original goal is still achievable, if the nation will just realize its importance and act quickly.

CLOSING REMARKS:

The issues we are facing in undergraduate education are indeed tractable, and conferences such as the one here in Ann Arbor can be useful in helping identify the desired solutions, if clear actions items are extracted and pursued vigorously.

A POSTSCRIPT:

COMMENTS IN REAL TIME

At the start of the conference I passed a copy of my talk to a young colleague in the University of Michigan Department of Physics, Gregory Snow. He is a NSF PYI recipient and is very committed to undergraduate teaching at the introductory level. He was kind enough to review the draft and to transmit to me via electronic mail some of his own comments. Given the ease with which such information can be downloaded -- and given the eloquence and relevance of his remarks, I have decided to append excerpts here and make them a part of this paper:

"In your section on "causes of present situation", while listing the items that make people concentrate on research and not on teaching, you could make the point that this is especially true for young faculty who know their tenure is based primarily on their research efforts and success. I have been told by senior professors – "Don't let it be known that you like to teach – it's the kiss of death".

One point that comes to mind when I read the sentence "Every department should aspire to recruit as many faculty as possible that are outstanding in both teaching and research." I was hired not long ago, and I was on the high energy search committee last year. In neither case did I feel there was any attention paid whatsoever to the candidate's potential as a teacher. I can absolutely attest to that fact in the case of the search committee – the overwhelmingly largest concern was the potential to lead a top-notch research program. Letters of reference almost never mention potential as a teacher. I have heard it said that you can judge a person's potential as a teacher by the technical seminar he/she gives, but I believe the seminar (rehearsed, covering topics the candidate has been dealing with almost exclusively for years) does not necessarily reflect the person's ability to communicate basic concepts effectively, at the right level, to be able to evaluate students' needs and difficulties.

On the subject of undergraduate research participation – our department's summer research awards are a tremendous step; I have been able to give opportunities to two very bright undergrad physics majors through this program. But I was very disappointed the year before (1987) when I applied to the REU program of the NSF to fund a student to work at CERN in an active, running experiment and was turned down. The same semester, two or three similar proposals from High energy people in the department were rejected, and it made me wonder what the heck they were looking for. Fortunately, I was able to support the student anyway at CERN, although it made my research resources very tight. He went on to graduate school in physics at Princeton.

I think the most important thing to stress, in addition to what you have, is that special incentives should be investigated to get young, active, enthusiastic physicists involved in hot research topics into the introductory courses. To engender en-

thusiasm in science, there is nothing better that an energetic person giving the lectures who is "almost a peer". When I give my special lecture in Physics 140 on particle physics and talk about working at the accelerator laboratories while showing aerial slides of the labs, the experiments, the apparatus, the W and Z event pictures, you can feel the excitement in the room. At the end of this lecture, I am bombarded by people coming to the front of the lecture room wanting to know more . I think this adds to their appreciation of the actual course material when they see that researcher putting their energies into explaining the elementary topics clearly on the blackboard.

A lot of the real potential in any department lies in the young people doing frontier research, and some of this energy should be channelled to the freshmen. Young people teaching these large courses are too often discouraged. "

Mr. VALENTINE. Thank you, sir.

Dr. Nelson?

STATEMENT OF DR. GORDON L. NELSON, DEAN, COLLEGE OF SCIENCE AND LIBERAL ARTS, FLORIDA INSTITUTE OF TECHNOLOGY AND CHAIRMAN, EDUCATION COMMITTEE, COUNCIL OF SCIENTIFIC SOCIETY PRESIDENTS

Dr. NELSON. My name is Gordon Nelson. I am Secretary of the Council of Scientific Society Presidents, Chair of CSSP's Committee on Mathematics and Science Education, former President of the American Chemical Society, and Dean of the College of Science and Liberal Arts at the Florida Institute of Technology.

The Council of Scientific Society Presidents is made up of the presidents and other members of the presidential successions of 56 professional scientific societies with a combined membership of 1.4 million. CSSP membership spans the full spectrum of physical, mathematical, and life sciences. I am here to register CSSP endorsement of the Science, Engineering, and Mathematics Educator Award Program contained in Section 6 of the subcommittee's draft education bill and support for this subcommittee's efforts to respond to the Nation's crisis in science and mathematics education.

Universities have three missions: teaching, research, and service. The three missions are seldom understood outside academia, and perhaps not always within. Tension between teaching and research is as old as research universities. Most prestigious research universities and those aspiring institutions seem to emphasize research and publication, not teaching ability, for tenure, promotion, and raises. Research oriented faculty appear to consider teaching oriented colleagues in lesser light.

Research grants and publication can be counted and evaluated. While the amount of teaching is measurable, quality in teaching is less so. There is little question, therefore, that there is need for renewed interest on teaching in the undergraduate science classroom.

The Council shares the committee's concern about the quality of undergraduate science education. To ensure substantial improvement in this area, the rewards associated with educating should be comparable to those associated with research, and faculty should be encouraged to devote time and attention to the advancement of undergraduate education.

A National Science Foundation program with these aims is clearly warranted. The Science, Engineering, and Mathematics Educator Award Program is specifically designed to restore a measure of visibility and prestige to educating undergraduate students and to encourage faculty contributions to the enhancement of teaching at the undergraduate level. We believe it is a crucial step in long-term efforts to raise the quality of math and science education for all students, not just for those with science careers in mind.

The award nature of this program is essential to fulfilling its intended objectives. With that in mind, the following recommendations are made for Section 6.

In Section 6(a)(3), the provision of three months salary support should be increased to six months salary support, permitting the award to be used for sabbatical in addition to summer salary. In

Section 6(b)(1)(A) and Section 6(b)(1)(B), the word "applicant" should be replaced with the word "nominee."

Section 6(b)(1)(C) and Section 6(b)(2) should be deleted to dispose of the proposal grant nature of what truly ought to be an award based upon individual achievement and potential. A report to the NSF at the end of the award period detailing the activities undertaken by the awardee and the significance of those activities for science, mathematics, and engineering education would be an appropriate requirement.

In summary, this program must focus on awards to individuals for achievement, not a product, if it is to have its intended effect.

CSSP's Committee on Mathematics and Science Education recently had the opportunity to review and formulate substantive comments on S. 2114. Paralleling those comments on the Senate bill, I have a few comments on the other sections of the draft House bill.

First, on instruction technologies, we strongly support the principle of promoting the development and use of innovative technologies for instruction in science and mathematics. A month ago, in fact, we adopted a resolution endorsing the use of technology, active experimentation, encouragement of creativity, and the application of knowledge in science and mathematics teaching.

On informal science education, CSSP endorses increased Federal funding for science and technology museums and centers. The role of informal science education is crucial to nurturing the natural curiosity and interest children have in science and to facilitating adult science literacy.

On technician training, CSSP has reservations about the merits of placing technician training programs within the National Science Foundation. As such programs are reminiscent of private sector initiatives and responsibilities, perhaps an agency with closer ties to industry, for example, the Department of Commerce, should implement Federal programs of this nature to the degree that they are warranted.

On associate degree-granting college/university partnerships, CSSP believes that, because community college/university two-plus-two partnerships presently exist in ever increasing numbers, Federal support would be duplicative of ongoing initiatives, and thus recommends that the resources provided in this subsection be redirected to programs with higher priority.

On graduate fellowships, we strongly endorse an increase in NSF graduate fellowships. However, we are concerned that the change proposed in Section 7(a) might result in increased competition among students for very limited financial assistance.

In conclusion, on behalf of CSSP, I would like to express our deep appreciation for your leadership in attempting to improve science, mathematics, and engineering education in the United States. Mr. Brown's proposal for a science, engineering, and mathematics educator award program is a worthwhile investment of resources in the much needed revitalization of undergraduate education.

We would be pleased to provide assistance as the legislation develops further and would like to be of such assistance as we can during the subsequent appropriations process.

I would be pleased to respond to any questions or comments that you might have. Thank you for the opportunity to present these remarks.

[The prepared statement of Dr. Nelson follows:]

COUNCIL OF SCIENTIFIC SOCIETY PRESIDENTS

Statement on

Proposed Mathematics and Science Education Programs

before the
Subcommittee on Science, Research, and Technology
Committee on Science, Space, and Technology
U.S. House of Representatives

presented by
Gordon L. Nelson
Secretary
and
Chair, Committee on Mathematics and Science Education
Council of Scientific Society Presidents

2318 Rayburn House Office Building
June 7, 1990

Mr. Chairman, Members of the Subcommittee:

My name is Gordon L. Nelson. I am Secretary of the Council of Scientific Society Presidents (CSSP), Chair of CSSP's Committee on Mathematics and Science Education, former President of the American Chemical Society, and Dean of the College of Science and Liberal Arts at the Florida Institute of Technology.

The Council of Scientific Society Presidents is made up of the presidents and other members of the presidential successions of 56 professional scientific societies with a combined membership of 1.4 million. CSSP membership spans the full spectrum of physical, mathematical, and life sciences.

I am here to register CSSP endorsement of the Science, Engineering, and Mathematics Educator Award Program, contained in Section 6 of the subcommittee's draft education bill, and support for this subcommittee's efforts to respond to the Nation's crisis in science and mathematics education. (Attached is a letter to the Honorable George Brown conveying CSSP's strong support for H.R. 2270, the original legislative vehicle for the Educator Award Program, authored by Mr. Brown.)

UNDERGRADUATE EDUCATION

Universities have three missions: teaching, research, and service. The three missions are seldom understood outside academia, and perhaps not always within. Tensions between teaching and research is as old as research universities. Most prestigious research universities, and those aspiring institutions, seem to emphasize research and publication--not teaching ability--for tenure, promotion, and raises. Research-oriented faculty appear to consider teaching-oriented colleagues in lesser light. Research grants and publications can be counted and evaluated. While the amount of teaching is measurable, quality in teaching is less so. There is little question that there is need for renewed interest in the presentation of knowledge in the undergraduate science classroom.

The Council shares the Committee's concern about the quality of undergraduate science education. To ensure substantial improvement in this area, the rewards associated with educating should be comparable to those associated with research, and faculty should be encouraged to devote time and attention to the advancement of undergraduate education.

A National Science Foundation (NSF) program with these aims is clearly warranted. The Science, Engineering, and Mathematics Educator Award Program is specifically designed to restore a measure of visibility and prestige to educating undergraduate students and to encourage faculty contributions to the enhancement of teaching at this level. We believe it to be a crucial step in long-term efforts to raise the quality of math and science education for all students, not just those with science careers in mind.

It is the "award" nature of this program that is essential to fulfilling its intended objectives. With that in mind, the following recommendations are made:

1) In Sec. 6(a)(3) the provision of three months salary support should be increased to six months salary support, permitting the award to be used for sabbatical in addition to summer salary.

2) In Sec. 6(b)(1)(A) and Sec. 6(b)(1)(B), the word "applicant" should be replaced with the word "nominee".

3) Sec. 6(b)(1)(C) and Sec. 6(b)(2) should be deleted to dispose of the proposal/grant nature of what truly ought to be an award based upon individual achievement and potential. A report to the NSF at the end of the award period detailing the activities undertaken by the awardee and the significance of those activities for science, mathematics, or engineering education would be a more appropriate requirement.

In summary, this program must focus on awards to individuals for achievement, not a product, if it is to have its intended effect.

ADDITIONAL OBSERVATIONS ON THE SUBCOMMITTEE'S DRAFT EDUCATION BILL

CSSP's Committee on Mathematics and Science Education recently had the opportunity to review and formulate substantive comments on S. 2114. (Attached is a letter to Senators Kennedy and Hatfield, the authors of the bill, conveying those comments.) Paralleling our comments on the Senate bill, I have a few comments on the other sections of the draft House bill.

Instruction Technologies

We strongly support the principle of promoting the development and use of innovative technologies for instruction in science and mathematics. A month ago, in fact, we adopted a resolution (attached) endorsing the use of technology, active experimentation, encouragement of creativity, and the application of knowledge in science and mathematics teaching.

Informal Science Education

CSSP endorses increased federal funding for science and technology museums and centers. The role of informal science education is crucial to nurturing the natural curiosity and interest children have in science and to facilitating adult science literacy.

Technician Training

CSSP has reservations about the merits of placing technician training programs within the National Science Foundation. As such programs are reminiscent of private sector initiatives and responsibilities, perhaps an agency with closer ties to industry, for example, the Department of Commerce, should implement federal programs of this nature to the degree that they are warranted.

Associate-Granting-College/University Partnership

CSSP believes that because Community College/University partnerships presently exist in increasing numbers, federal support would be duplicative of ongoing initiatives, and thus recommends that the resources provided in this subsection be redirected to programs of higher priority.

Graduate Fellowships

We strongly endorse an increase in NSF graduate fellowships. We are, however, concerned that the change proposed in Sec. 7(a) might result in increased competition among students for limited financial assistance.

CONCLUSION

On behalf of CSSP, I would like to express our deep appreciation for your leadership in attempting to improve science, mathematics, and engineering education in the United States. Mr. Brown's proposal for a Science, Engineering, and Mathematics Educator Award Program is a worthwhile investment of resources in the much-needed revitalization of undergraduate education.

Thank you for the opportunity to present these remarks. We would be pleased to provide assistance as the legislation develops further, and to be of such assistance as we can during the subsequent appropriations process. I would be pleased to respond to any questions or comments you might have.

COUNCIL OF SCIENTIFIC SOCIETY PRESIDENTS
1155 16th St., N.W., Washington, D.C. 20036 (202) 872-4452

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January 8, 1990

The Honorable George E. Brown, Jr.
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Brown:

At the recent semi-annual meeting of the Council of Scientific Society Presidents (CSSP), the members had the opportunity to consider a variety of issues in math and science education. Upon review of your Science, Engineering, and Mathematics Educator Award Act, H.R. 2270, the Council voted to support enthusiastically the program the legislation would establish.

As you know, the Council shares your concern about the quality of undergraduate education. To ensure substantial improvement in this area, the rewards associated with educating should be comparable to those associated with research, and undergraduate professors should be encouraged to devote time and attention to the advancement of postsecondary education. A National Science Foundation program with these aims is clearly warranted.

The program outlined in H.R. 2270 is specifically designed to restore a measure of visibility and prestige to the task of educating undergraduate students and to encourage professors to contribute to the enhancement of teaching at this level. We believe it to be a critical step in long-term efforts to raise the quality of postsecondary math and science education. One suggestion we would like to make is that some provision be made to ensure that younger faculty members get opportunities to receive and make use of these awards.

As Chairman of the Council, I would like to express our appreciation for your leadership in advancing science, engineering, and mathematics education. I would welcome the opportunity to offer further testimony on behalf of this most important legislation.

Sincerely,

William F. Prokasy

William F. Prokasy
1990 Chairman

The views expressed by CSSP are those of its members and do not necessarily represent the official position of their respective organizations.

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COUNCIL OF SCIENTIFIC SOCIETY PRESIDENTS
1155 16th Street NW, Washington DC, 20036 • 202/872-4452 • FAX 202/872-4615

May 30, 1990

The Honorable Edward M. Kennedy
The Honorable Mark O. Hatfield
United States Senate
Washington, D.C. 20510

Dear Senators Kennedy and Hatfield:

The Committee on Mathematics and Science Education of the Council of Scientific Society Presidents (CSSP) met recently and devoted most of its agenda to reviewing in great detail the "Excellence in Mathematics, Science, and Engineering Education Act." The Committee, made up of the presidents and presidents-elect of 20 professional scientific and science education societies, deliberated at length and arrived at consensus recommendations on the general thrust of this legislative package and on means to strengthen its worthwhile provisions.

The Committee would like to express its deep appreciation for your leadership in promoting an effective federal response to the Nation's crisis in mathematics and science education. Your diligence and perseverance are to be commended and will surely lead to the revitalization of mathematics and science education for students in the United States.

It is the Committee's general opinion that the funding level provided in the legislation is about one-fifth the level needed to achieve its intended objectives. A highly selective prioritization of objectives is therefore imperative if resources are to be focused on programs with the highest potential to improve the state of mathematics and science education.

We have attached a section-by-section recommendation on the relative priority of each initiative and, in some cases, on the optimum design of the initiatives included in the bill's substantive titles.

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The views expressed by CSSP are a consensus of its members and do not necessarily represent the official positions of their respective organizations.

The Honorable Edward M. Kennedy
The Honorable Mark O. Hatfield
May 30, 1990
Page 2

Thank you for this opportunity to comment on your most welcome legislative package of education initiatives. We look forward to working with you further in support of the worthwhile objectives outlined in your proposal.

Sincerely,

William F. Prokasy

William F. Prokasy
Chair

Gordon L. Nelson

Gordon L. Nelson
Secretary and Chair,
Committee on Mathematics
and Science Education

Enclosure

cc: Members, Senate Committee on
Labor and Human Resources

COUNCIL OF SCIENTIFIC SOCIETY PRESIDENTS

COMMITTEE ON MATHEMATICS AND SCIENCE EDUCATION

COMMENTS ON THE "EXCELLENCE IN MATHEMATICS, SCIENCE, AND ENGINEERING EDUCATION ACT" (S. 2114)

MAY 30, 1990

SCIENTIFIC AND TECHNICAL LITERACY OF THE GENERAL PUBLIC

The Committee is concerned that the proposed National Institute of Technology and Learning is similar to existing organizations in structure and function. Consequently, we recommend that the legislation provide support for existing entities of this nature rather than establish a fundamentally new institute, or funds should be distributed to other sections of this Act.

The National Clearinghouse for Science, Mathematics, and Technology Education is an excellent mechanism for disseminating exemplary educational tools for use in pre-college classrooms. We would like to recommend, however, that the legislation provide for merit review of materials before inclusion in the clearinghouse database to ensure they reflect the current state of knowledge in the subject area. Moreover, periodic review should be conducted to ensure that materials remain of value.

The Committee recommends that the Regional Science, Mathematics, and Technology Education Consortiums be introduced as pilot programs in seven states through peer-reviewed regional competition. Moreover, it is recommended that funding be provided at a level of not less than $30 million per year. Additional funding should be provided for new consortiums upon the satisfactory review of the initial pilot program.

The Roving Master Teachers in Mathematics and Science should also be introduced as a pilot program with a funding level of at least $20 million. Funding should be targeted to those states that have redirected their resources to address their needs in science and mathematics education. Moreover, recipient states should encourage and support the certification and employment of math and science specialists. The Committee recommends that states be invited to compete for funding under this section through the issuance of a Request for Proposals (RFP). Emphasis should be on the pre-high school grades.

The Committee notes that Regional Mathematics, Science, and Technology Academies already exist in increasing numbers and recommends accordingly that the resources provided in this section be redirected to programs of higher priority. Furthermore, we are concerned that the proliferation of residential, year-long academies for mathematics, science, and technology will unduly isolate prospective scientists and engineers and their teachers from the rest of society thus perpetuating the separation and image problems that presently trouble these fields. However, summer academies for students and teachers engaged in science and mathematics might have particular promise.

The Committee believes that the Fellowships and Grants for Professional Enhancement, Community Extension, and Innovation in Informal Education are worthy yet should not be characterized as high priority programs.

The Committee strongly endorses funding for Science and Technology Centers and Museums and recommends that the word "mathematics" be inserted in those paragraphs calling for initiatives in "science and technology" and "science and engineering."

While we endorse funding for Public Television Programs in Science and Technology, we do not believe that requiring funds to be focused on technology programming in the first three fiscal years is particularly meritorious.

The Committee believes that the National Aeronautics and Space Administration (NASA) is already quite successful at supporting Science and Space Exploration Education initiatives and recommends that the resources provided in this section be redirected to programs of higher priority.

EDUCATION OF SCIENTISTS AND ENGINEERS

CSSP strongly endorses the Establishment of a Division of Undergraduate Mathematics, Science, and Engineering Education within the National Science Foundation.

The Committee believes that because Community College/University 2/4 Partnerships presently exist in increasing numbers, federal support would be duplicative of ongoing initiatives and thus recommends that the resources provided in this section be redirected to programs of higher priority.

The Committee recognizes the need for Departmental Bootstrap Grants, but is concerned that the proposal as written is not expressed clearly enough. As a result, a low priority is recommended.

The Committee strongly recommends that the Presidential Awards for Excellence in College Teaching be expanded to provide more comprehensive and more substantial support for excellence in college teaching and prefers the provisions of H.R. 2270, authored by Congressman George E. Brown, Jr.

The Committee fully supports the National Mathematics-Science Teacher Corps but is concerned that the establishment of a loan program within the National Science Foundation would create unwarranted demands on its administration.

The Committee strongly endorses an Increase in National Science Foundation Graduate Fellowships. However, we are concerned that the change proposed under Section 320(b)(2) would result in increased competition among American students for limited financial assistance.

TECHNOLOGY EDUCATION AND TRAINING

The Committee recognizes the need for a Technology and Education program but is concerned that the proposal as written is not specified clearly enough to achieve its intended objective.

The Committee believes that support for College and Company Technology Partnerships would be duplicative of private-sector initiatives now in place in increasing numbers and recommends that the resources provided in this section be redirected to programs of higher priority.

The Committees does not believe there is a compelling need for federal support for Technology Training Consortiums. Moreover, the Committee is concerned about monitoring and enforcing the procedures mandated under Section 404(g).

WOMEN AND MINORITIES IN MATHEMATICS, SCIENCE, AND ENGINEERING

The Committee strongly endorses Exemplary Visiting Professional Fellowships but believes it would be useful to direct the program to all pre-college students, from kindergarten to grade 12. Special attention should be given to ensuring that speakers and role models are appropriate for the audiences before which they appear.

The Committee fully supports the establishment of the Distinguished Visiting Professors program.

The Committee strongly endorses Undergraduate Fellowships in Mathematics, Science and Engineering for Women and Minority Students and notes that, because many of the prime candidates for such fellowship assistance lack significant financial resources, scholarship funding is essential to increasing the number of minority students who obtain bachelor's degrees in mathematics, science, or engineering.

The Committee recommends that not only research universities but also liberal arts colleges be able to participate in the formation of federally supported Minority College-University Partnerships.

COUNCIL OF SCIENTIFIC SOCIETY PRESIDENTS

RESOLUTION

ENDORSING CREATIVE, ACTIVE MATHEMATICS AND SCIENCE LEARNING AND TEACHING

WHEREAS mathematics and science education is a matter of national concern in our attempts to better ourselves and our environment; and

WHEREAS mathematics and science are creative and logical endeavors; and

WHEREAS mathematics and science involve exploring, experimenting, risking, testing, reasoning, predicting, and ultimately, applying knowledge; and

WHEREAS students who study science and mathematics in an innovative setting, using equipment and technology, and who apply knowledge achieve more than students who do not;

THEREFORE, BE IT RESOLVED that the Council of Scientific Society Presidents endorses mathematics and science teaching which, using equipment and technology, emphasizes active experimentation, thinking, and encouragement of creativity and the application of scientific and mathematical knowledge, especially to real problems of society.

Adopted by the

The Council of Scientific Society Presidents

May 9, 1990

Mr. VALENTINE. Thank you, Dr. Nelson.

Dr. Certain?

STATEMENT OF DR. PHILLIP R. CERTAIN, PROFESSOR OF CHEMISTRY, UNIVERSITY OF WISCONSIN—MADISON AND SCIENCE COORDINATOR, ALLIANCE FOR UNDERGRADUATE EDUCATION

Dr. CERTAIN. Congressman Valentine, my name is Phillip Certain and I am a Professor of Chemistry at the University of Wisconsin—Madison. I would like to begin my testimony by commending the subcommittee for the leadership it has taken throughout the eighties and now into the nineties to strengthen science education in our Nation.

I am a child of the Sputnik. I was 14 years old when Sputnik was launched, and I have benefitted all of my life from the work of this subcommittee and its predecessors and from the programs of the National Science Foundation, both in research and education.

Mr. Valentine, I might say that my nephew, Chris Forinash just graduated from Duke University in civil engineering and my son Andrew has just finished his sophomore year at Chapel Hill, so my family continues to benefit from strong science and engineering within the State of North Carolina.

They say in teaching, "If a butterfly flies into the room, teach the butterfly." Well, I am afraid it is not a butterfly that has flown into the room today with the announcement of the changes that have taken place at NSF. It is something more serious. Before I make remarks about the legislation, I would like to make a few comments about the changes that have taken place at the National Science Foundation.

The title of my testimony was "Influencing the Balance Between Teaching and Research at the Nation's Universities." Your task has become much more difficult by the actions at the NSF last week. I am not talking about adding the women and minority programs of the education directorate. This is long overdue and is an important component of the readjusting process. I am talking about removing from the leadership of the directorate the Nation's most forceful advocate for science education.

You may not be aware, but I was Chairman of the Chemistry Department at Madison while Dr. Shakhashiri was a faculty member there. Perhaps the highest praise I can give him is to state that he caused me as much grief as chairman as our most outstanding researcher. He is a very strong advocate for science education; and, as Mr. Bloch indicated, Mr. Bloch's boundary conditions are more restricted. He is in a position to balance things more. But there is a significant danger that in the actions that were taken last week, the balance between education and research within the National Science Foundation has undergone a significant change.

I have talked with at least one member of the National Science Board and came away with a much different impression than you have heard today. I believe it was John Kennedy who said that the problem with American foreign policy is that, by the time a person gets in a position to influence foreign policy, his or her views have been fixed for about 20 years; so, our foreign policy is always about 20 years out of date. Well, I think there is a lot of evidence that the top management in the National Science Foundation is acting from the point of view of views that were fixed long ago, and that actually the energy amongst the research faculty, particularly the young research faculty in this Nation, is quite different. I will elaborate on that in a second.

I am familiar at the State level with arguments between universities and legislatures about micro-management and the arguments that Mr. Brown and Mr. Bloch had earlier. I think that what public research universities are learning is that they need to be responsive to the people and that we need to listen carefully and that there is a role to play. Certainly, this subcommittee has played an important leadership role in strengthening science education, as I have mentioned.

I am Science Coordinator for the Alliance for Undergraduate Education. This alliance is formed by 12 of the Nation's largest public research universities. The members are committed not only to research but also to undergraduate education.

In April of this year, we cosponsored with the NSF education directorate a science education conference attended by more than 200 university faculty from across the Nation. Our intention there was to attract what I would call garden variety research faculty.

I would like to continue by recounting just two of the points that were developed by the participants at the conference. This provides the context and support for my remarks on the science educator award.

The first point is that science education is such an important national problem that research universities must give it high priority. Furthermore, the health of the research enterprise requires the infusion of Federal funds targeted at science education.

Science research faculty have a major responsibility for change in the Nation's attitudes toward incompetence in science, engineering, and mathematics. This includes not only change at the university level, but also change in K-12 education, the training of teachers, and an outreach in science literacy.

The second point is that the faculty at research universities have the primary responsibility both for the curriculum and for choosing who will be on the faculty and how they will spend their time. Thus, fundamental change in science education must be initiated at the level of individual science departments.

Turning now to the educator award program—the Alliance is engaged in vigorous discussions about science education. Although final positions have not been reached, I believe there is broad consensus on several key points.

The first one is that support for science cannot be viewed as a zero sum game. This is true both on the research side and the education side. Support for large coordinated projects should not mean concomitant decreases in funding of individual investigator research. This latter research is an essential resource for the Nation's scientific work force.

Likewise, support for the science educator award should not mean decrease of support for individual initiatives in science education. Indeed, this award program will create even more interest on the part of university faculty for NSF grants in science education.

Second, the Federal Government, through its grants and awards programs, significantly influences priority setting by the faculty at the Nation's research universities. While the Federal Government has a number of awards in the research area, it has few in the area of education. Thus, it is important to establish a prestigious education award.

The third point is that there is growing energy among the faculty at the Nation's research universities to adjust the balance between teaching and research. Leadership such as you have shown at the Federal level is timely and will be met with an enthusiastic response.

The feature of the awards program that supports both science education and research will be particularly attractive. I am sure that the recipient of the award from my university will receive as much recognition as someone elected to the National Science Foundation.[1]

Fourth, the National Science Foundation is the appropriate Federal agency to administer this award. It has the respect of the science and engineering community for its high standards of excellence.

The educator award program is both an award and a grant program. The award component recognizes important achievements and creates inspiration for others. The grant component allows the recipient to continue to grow and to make additional contributions. Both components are essential.

Within the NSF, the division on undergraduate science, mathematics, and engineering education is the obvious division to administer the award. This division has become an effective, credible, and attentive voice for undergraduate education and has acquired an excellent track record in administering programs. I am concerned, however, that this division may be dismantled under the new organizational structure.

I believe I heard the word "coordinator" used by Mr. Bloch when referring to undergraduate science education. As I mentioned, I am the science coordinator for the Alliance, and I was once warned by a colleague never to accept a job that has the word coordinator in the title. There must remain a strong focus for undergraduate science education. I agree with Dr. Neal that it can not be parcelled out to the research directorates.

An analogy within the university is the summer school budgets. Most universities have a separate budget for summer school. When I was department chair, it puzzled me as to why we had to bother with a separate budget. I asked the university president one day why that was and he said, "Well, because I know that if I just fold it in with the regular annual budget, the deans will eat it up." And that is exactly what will happen if the science education mission of the NSF is folded in with the research directorates.

Finally, I enthusiastically support the proposed legislation. Mr. Bloch suggested that other important programs have higher priority. I am not fully competent to deal with that, but I can say that all of NSF's programs will be improved by a more balanced faculty.

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[1] Witness indicated he intended to say "National Academy of Science."

I do have a few suggestions regarding the selection criteria. They are contained in my written testimony. I would like to emphasize one in particular, however. That is the one that Dr. Neal also mentioned. As presently constructed, the awards expect the recipient to maintain a limited but ongoing program of research. In terms of influencing the way faculty view their profession, it is essential for research oriented faculty to be eligible for this award. Within this context, there is no value in limiting the research activities of the recipient as long as the purposes of the award are being met.

Indeed, the very best role models are faculty who have large research programs, but who also value science education. They are in the best position to initiate fundamental change and to influence their colleagues to readjust the balance between teaching and research.

Thank you.

[The prepared statement of Dr. Certain follows:]

INFLUENCING THE BALANCE BETWEEN TEACHING AND RESEARCH IN THE NATION'S UNIVERSITIES

Testimony Presented To

U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Science, Research and Technology
Hearing on
Science and Technical Education

Draft Subcommittee Bill
Sec. 6. Undergraduate Science Education

To establish a Science, Engineering, and Mathematics Educator Award

to be administered by the National Science Foundation

June 7, 1990

by

Dr. Phillip R. Certain
Professor of Chemistry
University of Wisconsin-Madison

and

Science Coordinator
Alliance for Undergraduate
Education

June, 1990

Phillip R. Certain

Professor of Chemistry, University of Wisconsin-Madison. He received his B.S. and M.S. degrees from Emory University and his Ph.D. in Physical Chemistry from the UW-Madison in 1969. He was NATO Postdoctoral Fellow and Ramsey Memorial Fellow at the University of Manchester in 1969-70, Alfred P. Sloan Foundation Fellow 1974-78, and Fulbright-Hays Fellow and Guggenheim Fellow at Cambridge University in 1978-79. His research interests lie in quantum chemistry, intermolecular forces, perturbation theory, and atomic and molecular resonances states. He is the author of 55 scientific publications and has directed the research of seven Ph.D. students and five M.S. students. At the undergraduate level, he has taught introductory chemistry for both majors and nonmajors, and junior-level physical chemistry. At the graduate level, he has taught quantum mechanics and statistical mechanics.

He was chairman of the Department of Chemistry 1982-86; Associate Vice Chancellor for Academic Affairs 1986-89; and Acting Vice Chancellor for Academic Affairs 1987. He is the principal author of two UW-Madison documents: "The Madison Plan," the university's 1988 initiative to broaden access for minority students, faculty, and staff and to create a multicultural academic environment; and "Revitalizing the Undergraduate Experience," a 1990 plan to increase the quality of undergraduate education.

He has been the organizer of five scientific and educational conferences, the most recent one being "The Freshman Year in Science and Engineering", sponsored by the Alliance for Undergraduate Education and the National Science Foundation at the University of Michigan, April 6-7, 1990. He is currently Science Coordinator for the Alliance.

INTRODUCTION

I am appearing here today on behalf of the Alliance for Undergraduate Education to comment on the draft legislation to create a science educator award and to commend the Congress on the leadership it has taken throughout the 1980s and now into the 90s to strengthen science and engineering education in our nation.

The Alliance for Undergraduate Education was founded in 1986 by twelve of the nation's largest public research universities:

University of California, Berkeley
University of California, Los Angeles
University of Illinois
University of Maryland, College Park
University of Michigan
University of Minnesota
University of North Carolina at Chapel Hill
The Ohio State University
The Pennsylvania State University
University of Texas at Austin
University of Washington
University of Wisconsin-Madison

On July 1, 1990, four more institutions will join the Alliance:

University of Arizona
University of Florida
Indiana University
Rutgers, the State University of New Jersey

The member institutions are committed not only to research, but also to undergraduate education and outreach. A major goal of the Alliance is to foster major innovations in the way undergraduate science is taught, and to forge more intimate links between research and teaching.

In April, 1990, the Alliance sponsored a conference entitled "The Freshman Year in Science and Engineering," attended by more than 200 university faculty and other interested persons from across the nation. The goal of the conference was to initiate major revitalization of freshman science by bringing together individuals who have been working to improve introductory courses with research faculty who may or may not have been actively involved in the teaching of these courses. Out of this came both a statement of the problems and an agenda for revitalizing these courses. We focussed attention on introductory courses because it is in these courses that we have both the greatest opportunity of attracting young people into science and the greatest danger of repelling them from science.

I will begin my testimony with a brief report of the areas of broad consensus developed by the participants at the Conference. This provides the context and support for my remarks on the draft legislation, which begin on page 6.

I. The Centrality of Science Education

Science education is such an important national problem that research universities must give it high priority. Science research faculty have major responsibility for change in the nation's attitudes toward and competence in science, engineering and mathematics. This includes not only change at the university level, but also change in K-12 education, in the training of teachers and in outreach and science literacy. The problem of scientific literacy is as important as, and is tightly coupled to, the "pipeline problem." Research faculty are important role models for their students, many of whom go on to become teachers at all levels of the educational system, and for the general public, including school children.

II. The Commonality of Problems in Science Education

The problems faced by faculty in engaging the curiosity and creativity of beginning students of science are largely the same across the disciplines. These problems include a fixed view of what is in the introductory courses, an ignorance among the faculty about what is taught in the other disciplines, a lack of knowledge about the students and how they are assimilating what they are being taught, an "undesigned redundancy" in the educational system that forces students to learn some introductory points over and over in a succession of science programs, a feeling of boredom among both faculty and students, and a profound lack of curiosity about science on the part of most students.

III. The Importance of Communication

There have been notable successes and tremendous promise in the undergraduate and outreach programs at research universities, but the successes need to be communicated. The communication infrastructure that is so effective in research is not highly developed in teaching and outreach. There is a growing energy among research faculty to become involved in science education. Individual commitment is a prerequisite for systemic change, but the individual efforts need to be communicated and built upon.

IV. The Central Place of Students

Science education should accommodate itself to the students and not vice versa. This requires that the faculty know their students better than they do now. It requires new strategies for active involvement in learning and for increasing access to women and minorities. Science education in the United States is no longer in a position to choose arrogantly among the best and brightest of the nation's students. If the nation wants scientists and engineers it will have to develop methods to interest young people and to keep them interested. Like it or not, young people today, raised in an age of television and high powered marketing, will not become docile, accepting pupils just because they have entered university lecture halls.

V. The Importance of Outreach

The walls of the university should come down in order to broaden access and to draw upon the resources of the K-12 system, industry and the public. To a great extent, the majors in science are made at the pre-college level. At the university, they can be dissuaded from that decision, but it is unlikely that a student who has not already started on that path will have an experience that leads to a career in science. So universities are very dependent on what happens at the pre-college level. Universities also have a great impact on what happens at the pre-college level through their training of teachers and through their admission criteria. Public research universities must also have support from the industries into which their science graduates go, and from the general public whose tax dollars support its undergraduate programs. Educating scientists and engineers in a society that does not support or appreciate what they do is of limited value. Thus, research universities need to devote appreciable effort to public education and public understanding of science, and to listening to the public's concerns about science and engineering education.

VI. The Importance of Collaboration among the Disciplines

The walls between the disciplines should come down to enhance collaboration in revising the curriculum. The sciences today share a common enemies: curricula that no longer engage the students or the faculty; a student body that has lost its ability to be curious; faculty who have become disenchanted with teaching large lecture sections. These problems cut across the disciplines, and their solution will be applicable across the disciplines as well. Students are interested in problems of contemporary society, and these problems often have multifaceted science and technology components. Discipline-specific introductory courses are not able to tap the richness available in a full discussion of issues dealing with the environment, health, or technological innovation, however. An intentional effort needs to be made to engage engineers, mathematicians, and physical and biological scientists in the evaluation and redesign of first year courses.

VII. The Central Role of Academic Departments

Important questions should be asked and answered at the departmental level: What is important to know? What can be left out of introductory courses? What incentives do the faculty want to reward exemplary results in teaching? Faculty at research universities have the primary responsibility both for the curriculum and for choosing who will be on the faculty and how they will spend their time. Thus, fundamental change in science education must be initiated at the level of individual science departments. University administrations and state and federal agencies can encourage and nurture this process, but the faculty are the key.

VIII. The Role of Junior Faculty

Young faculty should be included in the process of change. The tenure system is an effective socialization process: a young faculty member who has been told for six years to put innovations in teaching near the bottom of the professional agenda cannot be expected to value it highly after tenure is achieved. There is much energy and creativity among young faculty, postdoctoral fellows, and graduate students for innovation in teaching and outreach to the public.

IX. The Role of the NSF

The health of scientific research over the next several decades depends upon an infusion of federal funds targeted at science education. These funds should be funneled through the Science and Engineering Education Directorate of the National Science Foundation. We commend the leadership of the NSF Division of Undergraduate Mathematics, Science and Engineering Education and the Science and Engineering Education Directorate. This central focus for undergraduate education is vital for long-term success. The problems we are discussing will not be solved by a 3-point plan or a 6-point plan, by half-hearted and diffuse efforts. Their solutions require sustained and creative efforts over the next generation. Thus a central focus and strong support is essential. We support the Congress and the Executive Branch in their initiatives to increase funding.

We are disappointed, therefore, by the signal that has been sent to the science community by the postponement of the initiative in introductory science curriculum development, and we urge that the initiative be fully funded. We are distressed by the early problems that have been encountered in implementing the laboratory equipment program for the universities. We strongly support this program and hope that the problems will be resolved quickly.

X. The Role of the Alliance for Undergraduate Education

The Alliance for Undergraduate Education should be a strong leader in science and engineering education. The conference participants suggested these strategies: setting up communication and information networks among the disciplines; promoting collaborative working groups on curriculum, teaching methods and other principles of education; encouraging science faculty, education faculty and K-12 interaction; establishing a Commission on the Freshman Year in Science and Engineering Education, to report in three years; establishing a speaker/workshop corps as a resource for universities and by giving visibility to exemplary teaching. These suggestions are being actively explored by the Alliance.

SCIENCE, ENGINEERING, AND MATHEMATICS EDUCATOR AWARD PROGRAM

The first comment to make is to commend the sponsors of this legislation for the leadership they are demonstrating in recognizing excellence in science, engineering, and mathematics education.

The Alliance is engaged in vigorous discussions about science education at public research universities. Although final decisions have not been reached, I believe that there is broad consensus on several key points:

1. Support for science cannot be viewed as a "zero sum" game. This is true both on the research side and the education side. Support for large, coordinated projects such as the SSC and the human genome project should not mean concomitant decreases in the funding of individual principal investigator research. This latter research is the principal source of the nation's scientific workforce. Likewise, support for the Science Educator Award should not mean decrease of support for individual initiatives in science education. Indeed, the initiation of this award program will create even more interest on the part of university faculty for NSF grants in science education.

2. The federal government through its grants and award programs significantly influences priority setting by the faculty at the nation's research universities. The question is not whether to have research or education; the two are inextricably linked. The question is the balance between the two. While the federal government has a number of awards

in the research area, it has few in the area of education. Thus, it is appropriate to establish a prestigious award within the jurisdiction of the National Science Foundation.

3. There is growing energy among the faculty at the nation's research universities to adjust the balance between teaching and research. The results of our Alliance conference testify to this. Leadership at the federal level is timely and will be met with an enthusiastic response. Our conference was attended by several members of the National Academy of Science and the National Academy of Engineering, and by many more faculty who sustain substantial research programs. The feature of the awards program that supports both science education and research will be particularly attractive. I am sure that the recipient of the award from my university will receive as much recognition as someone elected to the National Academy or receiving the National Medal of Science.

4. The National Science Foundation is the appropriate federal agency to administer this award. It has the respect of the science and engineering community for its high standards of excellence. It administers the Presidential Young Investigator Award program, which is perhaps the closest parallel on the research side to the proposed Educator Award. (I might state parenthetically that in my experience, the PYI recipients, chosen on the basis of their research promise, have demonstrated unusual initiative and creativity in teaching at an early stage in their careers.) The PYI program is both an award and a grants program, which is also a feature of the proposed legislation. The award component recognizes important achievement and creates inspiration for others. The grant component allows the recipient to continue to grow and to make additional contributions. Both components are essential.

Within the NSF, the Division on Undergraduate Science, Mathematics and Engineering Education is the obvious Division to administer the award. This Division has become an effective, credible, and attentive voice for undergraduate education, and has acquired an excellent track record in administering programs. The research directorates must be partners in evaluating the nominees for the Educator Awards, however, because the research portion of the nomination is essential. The research directorates must be sensitive to the goal of the award program to enhance undergraduate education. The predominant evaluative criterion should be excellence in science education. To put it in plain words: the research should be sound and hopefully fully competitive within the research directorates, but the primary emphasis must be on science education.

5. I enthusiastically support the proposed legislation, but I have a few suggestions regarding the Selection Criteria.

Hearing on Science and Technical Education
Subcommittee on Science, Research and Technology
Phillip R. Certain
June 7, 1990

As presently constructed,

a. the awards provide "an amount for curriculum enhancement." The nature of the activity in science education should be construed as broadly as possible. Curriculum is certainly important, but so is teacher training and renewal, informal science, and research into teaching and learning. I would suggest that the language be broadened to include all those science education activities currently being supported by NSF.

b. the awards can be made based on "institutional, regional, or national" contributions. In order to create an award that competes in prestige with research awards, the applicant must have national recognition. The universities and professional societies already provide an adequate number of local and regional awards.

c. the awards expect the recipient to maintain a "limited but ongoing program of research". In terms of influencing a change in the way faculty view their profession, it is essential for research-oriented, established faculty to be eligible for this award. Within this context, there is no value is limiting the research activities of the recipient as long as the purposes of the award are being met. Indeed the very best role models are faculty who have large research programs, but who also value science education. They are in the best position to initiate fundamental change and to influence their colleagues to readjust the balance between teaching and research.

Mr. **Valentine**. Thank you, sir.

Dr. Certain, you seem to stress that national recognition of contributions in science education is important. Could you give us some examples of the type of national recognition that you are talking about?

Dr. **Certain**. There are two parts to this, I guess. The reason I stress this is that, when we are trying to adjust the balance between teaching and research, we want to have an award which is as prestigious as the major awards on the research side.

For example, in the Presidential Young Investigator Awards, those are made on the basis of a person's ability to make contributions on the national level. That is one thing. As far as examples go, I can give you two from my own university.

Professor Paul Williams developed a very fast growing species of cabbage plants for his research in genetics research. It goes from seed to flower in about three weeks. He saw the potential for teaching school children about genetics using these plants because, in the course of a school year, they could undergo many generations. It is kind of the "fruit fly of the plant world." He developed a program where he has distributed the materials to use these seeds throughout the Nation.

The second example is from my own department of chemistry. Professor Art Ellis, who does research in inorganic chemistry saw a way to make very inexpensive kits to demonstrate superconductivity to school children. We have also distributed into the thousands of these kits at low cost to school districts.

This is a kind of national impact that I think will come out of our universities. There are lots of teaching awards at the local and regional levels, but we do not have the kind of prestigious award that this legislation is trying to create.

Mr. **Valentine**. Dr. Nelson, you stated that the key aspect of the undergraduate award program is that it be based on an individual's past performance and potential as a teacher, and not based on the contents of a proposal. In your opinion, should the bill language be more explicit regarding the criteria for selection?

Dr. **Nelson**. I think with the recommendations that we made that the criteria really need to be open. That is, what one wants to do by this award is really to build upon the diversity, the excellence, that is out there.

There are certainly faculty members who are outstanding research faculty who fit the mold that Dr. Certain was talking about. There are other faculty who come to my mind who are really science educators. They are in research science departments. They are the ones as well who really have not had the opportunity for recognition.

Really, that is what I think is exciting about this proposal. It really then leaves it to the institution to make their nomination and to make their case; to then allow the individuals who get that award to do their thing, to build from their careers, to give the maximum that they can in terms of creativity. I think that we will get far more benefit as a nation in that way by this very, very special program.

There are many other NSF grant programs. This should not be a grant; it should not be a program. It should be an award for past achievement certainly and also potential for future contribution. The awardee then ought to be able to exercise their full creativity, which is why the amount of the award needs to be $100,000 or $150,000 a year, the kind of amount that a research faculty member would get, to really exercise that creativity.

Mr. **Valentine**. Dr. Certain, do you think there should be more guidance in the legislation with respect to award criteria?

Dr. **Certain**. No. I think that the guidance in general should be kept broad. I think that it would cover both the kind of example that I gave and the example that Dr. Nelson gave.

I think the point that Dr. Neal and I were making is that you do not want to limit the number of people who are eligible. I would certainly expect that there would be a number of recipients of this award who were primarily science educators, but you also do not want to eliminate from consideration the kinds of examples that I mentioned to you.

Mr. **Valentine**. Dr. Neal, what do you think about this question of criteria? Are we talking about a grant or a proposal, or something that is a cross between the two?

Dr. **Neal**. My views on this, Mr. Chairman, are very similar to those of Dr. Certain. There will be two classes of individuals that you would be interested in. One is experienced science educators, but there is another class. That is young faculty who have demonstrated a deep interest and considerable talent in undergraduate instruction, but might not have built up a record of five or ten years of activity in this area that would qualify them if the language of the bill was really based totally upon years of experience or significant careers in science education.

That could be used to eliminate consideration of bright young people. In the conference that Dr. Certain referred to, there was considerable discussion about the importance of involving young faculty in undergraduate education.

I would think that if you have a young faculty member who has done a good job for a period of two or three years and has a clear set of proposed activities that they would do if he or she were successful in getting an award, then I would hope that the provisions of the bill would not exclude consideration of that type of individual.

Mr. **Valentine**. Mr. Boehlert?

Mr. **Boehlert**. I would like to ask all three of our panelists about the effect of making the award a nomination by the institution. Is that more or less effective than having an open-ended solicitation?

Dr. **Nelson**. I think that will help extensively in giving this award the kind of prestige that it ought to have. Certainly, the nomination—and nominations will come from a whole variety of kinds of institutions—but institutions will themselves have to pick and the peer process will allow the natural evolution of establishment of criteria. That is why the bill itself does not have to be extremely specific.

Having an institutional nomination, I think, raises the level of effect. If one does not have institutional nomination and has a lot of criteria, then one has just another NSF grant program. I don't think that is what this is about.

Mr. **Boehlert**. How about you, Dr. Neal?

Dr. **Neal.** I would like to support the previous statement, but also to emphasize that, if all that happened was that a single individual at a large university got an award, you would not necessarily have the impact that you are after.

Part of the impact comes from the turmoil that you generate within the university as nominees are being proposed by their departments, and faculty committees are trying to talk about who is the best teacher in a department, and up at a higher level, as candidates are compared from physics, chemistry, and biology—all of that is a literal bombshell. A bomb has been dropped on the university. The university has to deal with the question: who is the best teacher that we have for nomination to this program? Even though you are only making one award perhaps to that institution, you will have touched the lives of perhaps hundreds of people.

Mr. **Boehlert.** If we can follow through on that, what do you think then of Dr. George's suggestion for institutional criteria?

Dr. **Neal.** There will be an operational set of criteria developed, whether or not it is ever written down. But you should provide as few constrictions as possible. Different institutions, by the way, will have slightly different needs and views about what constitutes an extraordinary faculty member for this award. And that can be good so long as your basic goals are achieved.

Mr. **Boehlert.** How about you, Dr. Certain?

Dr. **Certain.** I was going to comment on Dr. George's suggestion that institutions have to commit themselves, for example, to adopt the products of the award winner's work. I think that the idea of getting an institutional commitment is certainly a common one on the research side of NSF. We are very familiar with matching funds and things like that.

You do have to be very careful in this particular area because no single faculty member has control over the curriculum. The curriculum is really determined by the faculty meeting as a body. It is hard for me to see that a faculty would give any of its members, no matter how distinguished, a kind of a blank check saying, "Please come up with a project and we will adopt it."

However, I do think that you can put some provisions into the legislation that would ask for the same sorts of institutional commitments that are common in other NSF programs. For example, several people have mentioned the three month—what I interpret to be—summer salary support. You could certainly put into the provision that the university match in some way some aspects of the proposal.

That in itself would indicate an institutional commitment to the outcome without tying the university's hands or making some inappropriate decisions about how the outcome of the research would be used before it was actually accomplished.

Mr. **Boehlert.** To follow up—are there ways that we could alter research grants to encourage teaching?

Dr. **Certain.** I believe that the research grants are probably in that direction of being altered somewhat in terms of encouraging—involving people in the research activity as an educational activity. Certainly, with our graduate students, we teach our graduate students by doing research. That is how we teach our graduate students.

There is movement toward going back again to increasing undergraduates in research, including high school teachers in research, including high school students in research, and so on. So that is one way in which, in a research setting, you can encourage that particular kind of education, but the issue of science education itself is much broader than participation in research.

Mr. **Boehlert**. I could not agree more, but that is where all the emphasis seems to be.

I don't mean to sound cynical but is there a danger that these awards will be viewed as sort of a second tier award for those who can't make it in research?

Dr. **Certain**. That is why I am suggesting in my testimony some things that you could do to get the prestige of the award up.

At my university every year, there are several people elected to the National Academy. There are several medal of Science winners, and so on. And this award is talking about one award in science education. I think that is one very important aspect of it.

The coupling of a research grant with an education grant, I think, is also very important because what you are really trying to do is take existing faculty members who perhaps have a latent interest in science education, but who think that they have to go out and get that next research grant in order to maintain credibility on the faculty, and saying, "Look, you can split your activities. You can include education activities along with your research activities." I think that is a very important part of the proposal.

Mr. **Boehlert**. Dr. Nelson or Dr. Neal, do you have any additional comments?

Dr. **Nelson**. None from me.

Mr. **Boehlert**. Dr. Nelson, is there any irony in rewarding teachers by giving them time off?

Dr. **Nelson**. There is a certain irony in that, I would think, yes.

Mr. **Valentine**. That's the way we reward Congressmen. [Laughter.]

Dr. **Nelson**. That is why I really think that that is the exciting thing about the award proposal. That is why it should not be prescripted as to precisely how one is to do X, Y, and Z and that you are going to have a proposal and it is going to deliver a product and so forth. It seems to me that that is what the nomination process is precisely about.

We have intense diversity in the kinds of higher education institutions that we have. I think that the peer review process can very clearly identify those nominees who are very special and worthy of this award.

It may well be that the awardee does take a sabbatical. It may well be that the individual uses it for summer salary. The individual may well use that award for a whole variety of other things that may increase that individual's presence in the classroom, but I think that is what ought to be left up to the institution of the nominee.

Mr. **Boehlert**. Fine. Thank you all for a very excellent testimony and for being very valuable resources for this subcommittee. We appreciate it.

Thank you, Mr. Chairman.

Mr. **Valentine**. Thank you, Mr. Boehlert.

We thank all three of you again for being here today, for the time that went into your preparation to be here, and for the contribution that you make in your professions and in assisting us to address what is the number one problem facing this nation and how to correct the problem. How do we treat the disease in this country that has education apparatus and the delivery of quality education in many areas on an inclined plane?

We invite you to share any other thoughts you have with us. I am not inviting you to send us a bale of stuff, but if anything else occurs to you, it will be welcome.

Thank you all, and the subcommittee will stand adjourned.

[Whereupon, at 1:40 p.m., the subcommittee was adjourned.]

SCIENCE AND TECHNICAL EDUCATION

THURSDAY, JUNE 14, 1990

U.S. House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Science, Research and Technology,
Washington, DC.

The committee met, pursuant to recess, at 1:34 p.m., in room 2318, Rayburn House Office Building, Hon. Tim Valentine (chairman of the committee) presiding.

Mr. Valentine. The hearing will come to order.

This afternoon, we will conclude two days of hearings on proposed legislation to create several new science and technology education programs at the National Science Foundation.

Last Thursday, we received testimony from the Director of the National Science Foundation on the Administration's position on this legislation. Also, we received testimony from the Vice President of the Carnegie Foundation on the Advancement of Teaching and several representatives from academia on the proposal in the draft bill for establishment of an undergraduate education awards program.

In the hearing today, we will explore other provisions in the draft bill, including a program of support for science museums to strengthen informal science education, which is based on H.R. 3154, which was introduced by our colleague, Mr. Brown, who is here today; a program to expand the development and use of education technologies based on H.R. 3122, introduced by Mr. Price, and H.R. 4331, introduced by Mr. Buechner; and the programs based on S. 2114, introduced by Senator Kennedy. Senator Kennedy's proposed legislation would double the size of the NSF Graduate Fellowship Program and encourage partnerships between two-year and four-year academic institutions for the purpose of increasing the transfer of two-year students to baccalaureate programs in science and engineering.

Our intention in this hearing is to obtain a critical evaluation of the provisions of the draft bill. In particular, we invite the witnesses to comment on whether the proposed programs are tailored to address the most important issues and whether the programs are likely to achieve their intended objectives.

We welcome our distinguished witnesses to today's hearing and look forward to their testimony and to the discussions which we will have with you.

Before I yield to my colleagues, let me read the list of witnesses. The first panel will consist of Dr. Shirley M. Malcom, who is Head, Directorate for Education and Human Resources, American Association for the Advancement of Science.

Panel two consists of Dr. Dennis Wint, Vice President, Association of Science-Technical Centers and President of St. Louis Science Center, St. Louis, Missouri; Ms. Ilma Levine, who is Director of Sciencenter, Ithaca, New York; Mr. Roy Shafer, President, Ohio's Center of Science and Industry in Columbus, Ohio; and Dr. Thomas Krakauer, Director, North Carolina Museum of Life and Science, Durham, North Carolina.

Panel three will be Mr. Dallas Garrett, who is Dean for Business, Health and Technology, Central Piedmont Community College, Charlotte, North Carolina; and Mr. Jack B. Evett, Associate Dean, College of Engineering, University of North Carolina at Charlotte.

The fourth and final panel will be Mr. Theodore H. Allison, Human Resources Consulting Services, Ferguson, Missouri; and Ms. Theresa Stanion, Director of Government Relations, International Communications Industries-Association of Fairfax, Virginia.

I yield to our ranking member, Mr. Boehlert, for his opening statement.

Mr. BOEHLERT. In the interest of time, Mr. Chairman, I ask unanimous consent that my opening statement appear in the record at this point.

Mr. VALENTINE. Without objection.

[Mr. Boehlert did not submit an opening statement.]

Mr. VALENTINE. Mr. Brown?

Mr. BROWN. I'll make the same request, Mr. Chairman.

Mr. VALENTINE. Without objection.

[The prepared opening statement of Mr. Brown follows:]

SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY
HEARING ON SCIENCE AND TECHNICAL EDUCATION

SECOND PANEL
STATEMENT ON THE SCIENCE MUSEUM ASSISTANT ACT

BY
GEORGE E. BROWN, JR.
JUNE 14, 1990

I WOULD LIKE TO WELCOME THE SECOND PANEL WHICH WILL ADDRESS THE ISSUE OF SCIENCE AND TECHNICAL EDUCATION IN THE CONTEXT OF INFORMAL EDUCATION.

THE NATIONAL SCIENCE FOUNDATION'S (NSF) REPORT ON ITS LONG RANGE PLAN FOR FY89-93 GETS TO THE HEART OF THE IMPORTANCE OF INFORMAL EDUCATION. THE REPORT STATES THAT "MOST PEOPLE, MOST OF THE TIME, LEARN MOST OF WHAT THEY KNOW OUTSIDE OF THE CLASSROOM. THIS KIND OF INFORMAL LEARNING IS VITAL AS A COMPLEMENT TO FORMAL EDUCATION AND AS A MECHANISM FOR HELPING MAINTAIN THE SCIENCE AND TECHNOLOGY LITERACY OF THE GENERAL POPULATION."

IN THE DRAFT LEGISLATION YOU HAVE REVIEWED FOR TODAY'S HEARING THERE IS A SECTION WHICH WOULD CREATE MECHANISMS AT THE NSF TO FACILITATE THE EXCHANGE OF SUPERIOR EDUCATION PROGRAMS FROM ONE MUSEUM TO ANOTHER. IT WOULD ALSO EXTEND THE CURRENT

Informal Science Education (ISE) grants at NSF to encourage science museums to develop innovative approaches to dealing with the problem of science illiteracy in our country. Let me be perfectly clear, this legislation would NOT require NSF to create a new program within ISE, only to enhance the current ISE program. By fostering both formal and informal science education, this legislation would help increase science and technology literacy in America.

Despite the important role they play in science education, these institutions face two major problems today. One has to do with the dissemination of excellent education programs for use by other museums. The second has to do with the problem of funding new museum projects. Both of these problems are addressed in the legislation we are discussing today.

The science and technology literacy of our citizens is vital to the continued cultural and economic growth of our nation. Science museums are an important path to science and technology literacy, and we should do everything possible to foster their development. I hope our panelists will take advantage of this opportunity to comment on this legislation and to provide any other suggestions which might help us attain our goal of improved science literacy in this our country.

Mr. VALENTINE. Mr. Buechner?

Mr. BUECHNER. Mr. Chairman, I, too, would like to limit my opening remarks but ask that the total of the remarks be entered in the record. But I certainly want to thank you for what you've done today, and I'm particularly interested in how we're going to respond to the OTA assessment that the key obstacle in the United States competitiveness and information age economy is the poor productivity of the education sector in research and development.

That's why, I know that you're aware, I introduced H.R. 4331, the National Learning Technology Act, and I would really hope that we pull out something from this subcommittee and then go to the committee of the whole that does say to the United States that we are concerned about where the United States is going to be on the technology race that's going to hopefully take the place of the arms race.

So, as I said, in the interest of time, I'd like to have my other remarks entered into the record but, once again, compliment you and Mr. Boehlert for your work in amalgamating all these various pieces of legislation.

Mr. VALENTINE. Without objection.

[The prepared opening statement of Mr. Buechner follows:]

CONGRESSMAN JACK BUECHNER

MR. CHAIRMAN, TODAY THE SUBCOMMITTEE WILL CONCLUDE A TWO PART SERIES OF HEARINGS ON SCIENCE AND TECHNICAL EDUCATION. IT HAS BEEN REPORTED BY THE CONGRESSIONAL OFFICE OF TECHNOLOGY ASSESMENT (OTA) THAT A KEY OBSTACLE IN A U.S. SHIFT TO AN INFORMATION AGE ECONOMY IS THE POOR PRODUCTIVITY OF THE EDUCATION SECTOR IN RESEARCH AND DEVELOPMENT. TO CORRECT THIS DEFICIENCY, I INTRODUCED THE "NATIONAL LEARNING TECHNOLOGY ACT", H.R. 4331, WHICH IS SECTION 3: INSTRUCTION TECHNOLOGY OF THE "SCIENCE AND TECHNOLOGY EDUCATION ACT OF 1990".

WE ARE HERE TODAY TO LEARN MORE ABOUT HOW WE, AS LEGISLATORS, CAN REACH OUT TO OUR SCHOOL SYSTEMS AND TO THE WORKFORCE TO ENHANCE U.S. SCIENCE AND TECHNOLOGICAL LITERACY. IF WE ARE TO MEET THE TECHNOLOGICAL CHALLENGES OF TODAY AND OF THE FUTURE, WE MUST HAVE A SCIENTIFICALLY LITERATE PUBLIC. THIS EDUCATION PACKAGE SERVES WELL IN EMPHASIZING MANY ISSUES RELATED TO THIS OBJECTIVE INCLUDING INSTRUCTIONAL TECHNOLOGIES, INFORMAL EDUCATION, TECHNICIAN TRAINING, UNDERGRADUATE EDUCATION, AND GRADUATE FELLOWSHIPS. ALL OF THESE ISSUES ARE CRUCIAL TO AN INFORMATION-AGE SOCIETY. THE 1990'S ARE UPON US, AND WE MUST NOW ENGAGE OURSELVES IN PREPARATION FOR THE 21ST CENTURY. I BELIEVE THAT THE TIME HAS COME FOR A LONG-TERM COMMITMENT ON OUR PART TO IMPROVE THE PROGRESS AND FOCUS OF OUR EDUCATIONAL SYSTEM.

IN SUM, MR. CHAIRMAN, WE ARE ON A MISSION TO ENSURE AMERICA'S SCIENTIFIC, ENGINEERING AND TECHNOLOGICAL WELL BEING. HOWEVER, THAT MISSION CANNOT BE ACHIEVED WITHOUT IMPROVING OVERALL SCIENTIFIC, MATHEMATIC AND TECHNOLOGICAL LITERACY THROUGH EDUCATION EFFORTS AT ALL LEVELS, FROM PRE-SCHOOL THROUGH POST-DOCTORAL STUDIES.

MY LEGISLATION, H.R. 4331, NOW SECTION 3 OF THE PACKAGE, PROVIDES A MERIT-BASE GRANT PROGRAM FOR THE DEVELOPMENT OF MATERIALS TO ENHANCE THE PRODUCTIVITY OF BASIC EDUCATION AND ADVANCED INSTRUCTION. GRANTS WOULD BE AWARDED BY THE NATIONAL SCIENCE FOUNDATION FOR TECHNOLOGIES WITH THE POTENTIAL TO MAKE A SIGNIFICANT DIFFERENCE IN IMPROVING ELEMENTARY AND SECONDARY EDUCATION TEACHING.

IN JUST A FEW YEARS OUR SCHOOLS HAVE GONE FROM SLIDE RULES TO CALCULATORS TO COMPUTERS. SUCH RAPID CHANGES REQUIRES THAT WE TAKE STEPS TO ENSURE THAT OUR CHILDREN DO NOT FALL BEHIND IN THE WORLD OF TECHNOLOGY. H.R. 4331 WILL PROVIDE INCENTIVES TO DEVELOP TEACHING TOOLS THAT WILL MAKE OUR SCHOOLS MORE PRODUCTIVE AND RESPONSIVE. IN A TIME WHERE SO MUCH OF OUR GOVERNMENT SPENDING IS WASTED, THIS PROGRAM CLEARLY A WISE INVESTMENT IN ITS PUREST FORM, FOR IT IS INVESTMENT IN OURSELVES.

THE STORY OF THE FUTURE OF OUR COUNTRY IS WRITTEN EVERY DAY IN THE NOTEBOOKS OF OUR STUDENTS, AND IT IS ONLY THROUGH THEIR DETERMINATION TO UNDERSTAND SCIENCE AND MATH THAT OUR FUTURE COMPETITIVENESS IS GUARANTEED. IT IS INCUMBENT UPON

US TO PREPARE THEM FOR THE FIGHT TO REMAIN COMPETITIVE IN THE GLOBAL MARKETPLACE FOR TECHNOLOGY. ACCORDINGLY, I CONGRATULATE THE CHAIRMAN, VICE CHAIRMAN, AND MEMBERSHIP OF THIS COMMITTEE FOR THEIR EFFORTS WITH "THE SCIENCE AND TECHNOLOGY EDUCATION ACT."

THANK YOU MR. CHAIRMAN.

Mr. **Valentine**. Mr. Campbell?

Mr. **Campbell**. No statement. Thank you.

[The prepared opening statements of Mr. Bruce and Mr. Costello follow:]

THE HONORABLE TERRY L. BRUCE
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY
JUNE 14, 1990

MR. CHAIRMAN, THANK YOU FOR HOLDING SECOND OF THESE TWO IMPORTANT HEARINGS ON SCIENCE AND TECHNICAL EDUCATION. I BELIEVE THAT THE DRAFT OF THE BILL PREPARED BY OUR SUBCOMMITTEE IS AN EXCELLENT STARTING POINT FOR IMPROVING THE CONDITION OF OUR COUNTRY'S MATH AND SCIENCE EDUCATION, AND I LOOK FORWARD TO HEARING AN APPRAISAL OF THIS LEGISLATION BY OUR WITNESSES.

I, LIKE MANY OF MY COLLEAGUES ON THIS COMMITTEE, AM CONVINCED THAT THERE IS A DIRECT CORRELATION BETWEEN MATH AND SCIENCE EDUCATION AND OUR GLOBAL COMPETITIVENESS, STANDARD OF LIVING, AND OVERALL QUALITY OF LIFE. OUR ABILITY TO INNOVATE AND PRODUCE HIGH-QUALITY GOODS AND SERVICES IS DEPENDENT UPON THE DEVELOPMENT OF A HIGHLY SKILLED TECHNICAL WORKFORCE. WE AS A NATION CAN NO LONGER COMMIT THE ERROR OF ALLOWING OUR STUDENTS TO BE OUTPERFORMED IN THE CLASSROOM.

AGAIN, I LOOK FORWARD TO HEARING THESE TESTIMONIES TODAY AND NEXT WEEK, AND I AM CONFIDENT THAT THIS SUBCOMMITTEE WILL CONTINUE TO PLAY A LEAD ROLE IN IMPROVING MATH AND SCIENCE EDUCATION IN AMERICA.

OPENING STATEMENT

BY U.S. REP. JERRY F. COSTELLO, ILLINOIS

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

SCIENCE AND TECHNICAL EDUCATION

June 14, 1990

Mr. Chairman, today we gather to listen to a distinguished group of witnesses discuss the state of science education in our country. Again, it is a pleasure to address this wide-ranging science education bill that would create new grant programs for universities, two year colleges and science museums.

We have all heard a great deal about the sorry state of math and science education in our country, and we have heard a great deal about a new commitment to change this situation. This legislation would help improve the science education and public awareness of all ages in the United States.

Mr. Chairman, I look forward to hearing our witnesses today, and I thank you for convening this hearing on one of the most pressing topics the United States faces today.

Mr. **Valentine**. All right. Dr. Malcom, if you would come around with such associates and colleagues as you brought with you and might want to sit there. We welcome you here today, and your prepared remarks will appear in the record in toto, and we would ask you to summarize, please, ma'am, if you can.

STATEMENT OF DR. SHIRLEY M. MALCOM, HEAD, DIRECTORATE FOR EDUCATION AND HUMAN RESOURCES, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, WASHINGTON, DC

Dr. **Malcom**. Thank you very much, Mr. Chairman.

Mr. Chairman, members of the subcommittee, I want to thank you for inviting me to testify on the draft legislation on science education and human resources. I am Shirley Malcom, Head of the Directorate for Education and Human Resources Programs of the American Association for the Advancement of Science.

I will make some summary remarks, after which I'd be happy to try and answer any questions that you might have regarding the remarks or the full written testimony.

I am here today as an individual, as a person deeply concerned about science, mathematics and technology education and committed to working to improve the quality of such education for all students, to increasing the flow of young people into science and engineering careers, to expanding the talent base to include full participation by underrepresented groups, and to increasing the public understanding of science and technology.

I am sure that these are the issues which led to the development of this draft legislation, the issues which have brought us all here today. While the draft legislation has provisions aimed at all four of these broad themes, you have specifically asked me to comment on the two provisions dealing with concerns about the flow of talent to science and engineering, the 2- to 4-year articulation or transition concerns, and increased support for graduate fellowships, and to improving the quality of science, mathematics and engineering education by developing much more fully the potential of innovative, instructional technologies.

All of these provisions are primarily directed at the National Science Foundation, although the innovative technologies provision also targets the Office of Science and Technology policy and its monitoring and reporting function. Let me begin with brief comments about the last provision which I mentioned, that of the innovative, instructional technologies.

This is a big area to understand and to activate. I would urge the committee to look at the entire system in which technology might be used and to consider how a reasoned investment can help bring about the systemic approach. We must think and act beyond the schools, beyond 9 a.m. to 3:30 p.m., September to June. We must envision the kind of training, the level of school and community support that it will take to help make technology an effective tool for learning in the school as well as beyond the school.

We know an awful lot already. It is time to build on what we know, to take our demonstrations, our models, our small projects and to create a total strategy that makes technology a real tool for education.

The subcommittee is correct to voice its concern, as well, about the 2- to 4-year college relationship, especially in light of this subcommittee's other expressed interest in promoting increased participation by minorities in science, mathematics and engineering.

The disproportionate participation of minorities in post-secondary education by way of two-year institutions leads us naturally to a concern about the movement of students between these two kinds of institutions. I have expressed reservations in the written testimony, however, that while individual projects and activities may be undertaken under the legislation, coherent programming, which may be unique to addressing the particular problems of each institutional arrangement, may not be here.

The final point discussed in the testimony was providing double support for graduate fellowships. I devoted considerable space to this issue within the written testimony because of my belief that we need a comprehensive look that includes, but is not limited to, fellowships, about the best way to increase the available supply of doctorates, and to ensure that they receive the best education, mentoring and professionalizing experiences that we can provide.

Here the issues go beyond stipends to include other supports and socialization to the field. At present, we are using only a couple of the strategies—research assistantships and fellowships—which could be used to promote production of doctoral scientists and engineers. I would urge us to look more systematically at the entire set of provisions, including such things as traineeships and providing certain enriching experiences within the structure of the current fellowship program.

We need a system of solutions to address the system of problems that we face. This draft legislation is an excellent beginning in pointing out critical needs in areas of special concern and attention. I urge the committee to work with the Foundation and to request that they provide you with a strategic, coordinated plan of how they will address these issues in science education within the four large themes that I mentioned earlier.

While doing this, we must use what we already know. We must put the ideas together, drawing on the knowledge resident in the Congress and the Executive, in the States, and in the field. We need to use the natural experiments that are going on in many of the States to get even smarter about what works and the circumstances under which they work.

We have to get the current system better tuned to capture, analyze, evaluate and disseminate what we know, providing practical, hands-on technical assistance to those who want help with implementation. A patchwork approach to programming cannot do what we need to have done in science and mathematics education; a system of solutions can. I would be happy to entertain any questions.

[The prepared statement of Dr. Malcom follows:]

TESTIMONY BY

DR. SHIRLEY M. MALCOM

HEAD, DIRECTORATE FOR EDUCATION AND HUMAN RESOURCES PROGRAMS
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SUBMITTED TO

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

14 JUNE 1990

SHIRLEY M. MALCOM

Shirley Malcom is head of the Directorate for Education and Human Resources Programs of the American Association for the Advancement of Science (AAAS). The directorate includes AAAS programs in education, activities for underrepresented groups, and public understanding of science and technology. Dr. Malcom was head of the AAAS Office of Opportunities in Science, from 1979 to 1989. Between 1977 and 1979, Dr. Malcom served as program officer in the Science Education Directorate of the National Science Foundation (NSF). Prior to this, she held the rank of assistant professor of biology, University of North Carolina, Wilmington. Other work experience includes two years as a high school science teacher.

Dr. Malcom received her doctorate in ecology from the Pennsylvania State University; master's degree in zoology from the University of California, Los Angeles; and bachelor's degree with distinction in zoology from the University of Washington.

Dr. Malcom served on the Carnegie Forum Task Force on Teaching as a Profession, and as a member of the congressional mandated Task Force on Women and Minorities, and Handicapped in Science and Technology. She serves on the Education Advisory Council of the Carnegie Corporation of New York and as a member of the board of the National Center on Education and the Economy. From 1984 to 1986 she was chair of the National Science Foundation Committee on Equal Opportunities in Science and Technology. She is a member of the Smithsonian Advisory Council. Dr. Malcom has served on numerous boards, including the education advisory committee of the National Urban League. She has been nationally recognized for her efforts, and those of the Office, to improve the education of minority young people by involving community organizations and parents in education reform. In 1987 Dr. Malcom was recognized as one of five honored by the National Council of Negro Women (NCNW)/Frito-Lay "Salute to Black Women Who Make It Happen." In 1989 she received Humanitarian of the Year Award from the National Coalition of Title I/Chapter I Parents and the National Medical Association's Scroll of Honor. She is a past recipient of a Golden Gazelle from the Project on Equal Education Rights (PEER) of the NOW Legal Defense and Education Fund.

Mr. Chairman, Members of the Subcommittee

I am pleased to have an opportunity to testify before the Subcommittee on Science, Research and Technology of the House Committee on Science, Space and Technology. In particular I will comment on two sections of the proposed legislation which relate to issues at the postsecondary level of the pipeline for science and engineering. I will also provide comment on proposals to promote innovative uses of technology in instruction.

There is much concern in the science and engineering communities as well as among policy and business leaders about the future of the science, engineering and technical human resource base. Will we have adequate numbers of people who choose to be scientists, mathematicians, engineers and technicians? Will a shrinking population base, a changing demographic mix and declining interest in S/E majors and careers leave us with a shortage of personnel needed to drive a knowledge based economy?

Will the education these people receive be adequate in amount and type to ensure a steady flow of talent into our industries, into research, into government and into our schools, colleges and universities? Two of the programs proposed in the draft legislation seek to address problems in the pipeline at the undergraduate and graduate levels.

The Adequacy of the Doctoral Pool

There is considerable concern over the declining number of American college graduates in science and engineering who choose to continue for doctoral study in these fields. The losses from the potential doctoral pool are even greater for women and minorities. How do we encourage greater participation in graduate education in science, mathematics and engineering?

That question likely has many possible responses which require actions at much earlier parts of the pipeline; interventions are also possible at the point of transition between college and graduate education. In addition it is generally agreed that access to adequate financial support is a necessary condition for students to pursue graduate education in science and engineering.

It is logical that graduate fellowships would be presented as one possible strategy to encourage the production of doctorates in S/E fields. NSF fellowships have provided totally portable funding to very able students with a cost of education allowance to the institution. Students who receive such funding tend to cluster in a small number of research universities with 30 percent of fellows going to 4 institutions and 80 percent going to just 20 institutions. Portability gives the students maximum freedom. But the clustering of these students in a small number of institutions, coupled with the growing difference between the education allowance provided the institution by NSF in lieu of tuition and full cost of tuition, has created stresses in the relationship between NSF and some of our major research universities. Before increasing the number of fellowships perhaps we should encourage exploring such issues as the size of the stipend and the education allowance. How does the stipend amount compare with that of other highly selective awards; what proportion of wages which could be commanded by the students if they entered the workforce directly would need to be offered to students to get them to consider graduate education in lieu of direct entry into the job market? How much do they need to live? How does the buying power of the current stipend levels compare with past stipend levels, especially given recent changes in the tax laws?

On the issue of education allowance to universities how much is a fair allowance level? While portability may be ideal for self-directed independent students connecting to large research establishments, we must consider whether there are other kinds of support which might address our concerns about the numbers of highly talented doctoral students while additionally focusing on other issues, such as enhancing the research capacity of institutions, and increasing supply from particular groups or in particular fields or subfields. While I support graduate fellowships as an effective mechanism to increase Ph.D's, I believe that it is time to look at fellowships in the larger context of support provided for graduate education.

There are a wide variety of ways that students are supported in graduate education in science and engineering. Among these are personal and family sources (including loans), federal sources (including fellowships, research assistantships, traineeships) and university sources (especially teaching and research assistantships and to a lesser extent university fellowships). In testimony provided before the Senate Committee on Labor and Human Resources on April 19, 1990, Dr. Richard Atkinson, Chancellor of the University of California, San Diego (and AAAS Board Chairman) raised the issue of the declining significance of traineeships in the whole scheme of graduate support. This is a valid concern which deserves this Subcommittee's consideration. Is there a role for traineeships in the graduate support strategy of the National Science Foundation? Unlike portable fellowships and to a certain extent research assistantships tied to single investigator grants, traineeships have the potential to affect institutions as well as to support individuals. The predominant mechanisms now used by NSF to support doctoral study omit a key tool to build the capacity of departments to enhance research, mentoring and teaching capabilities through traineeships.

To summarize, rather than state as a goal to double the numbers of fellows, perhaps the adequacy of support within the current fellowship program should be considered as well as an exploration of traineeships as an additional and alternative form of support.

If we look at the structure of the current fellowship program, and especially at its capacity to prepare students for the most meaningful professional experiences, perhaps consideration should be given to providing a personal research allowance -- several thousand dollars which the student can access over the life of the fellowship to support participation in professional meetings and purchase of small equipment, materials, connect charges, etc., necessary to successful completion of the graduate program.

At present the success rate of students in the NSF fellowship program is fairly low. Somewhere around one in 7 students receives an NSF award. Many very able students are designated as honorable mentions. The competition thus serves an important role in identifying very talented students. As a way of recognizing the capability of these students and encouraging their pursuit of graduate education, NSF could consider providing small research and travel awards of $500 - $1,000 to those students who are recognized as honorable mentions and who go to enter graduate programs school in SME fields. Again, this is an additional mechanism to enhance the current program and encourage expanded participation in graduate education as an option to establishing as a goal a doubling of the number of fellowships.

Other provisions of Section 7 would expand eligibility for the fellowship competition to non-citizen permanent residents and encourage enhanced participation by women and minorities.

Expanding eligibility to non-citizens, while bringing additional talent to U.S. science and engineering, would seem to be a misplaced action at this time. Rather than solving the problem of expanding the supply of doctorates, it will likely exacerbate the difficulties in pursuing other goals such as expanding opportunities for women and minorities. It is estimated that increasing eligibility to non-citizen permanent residents will add some 7-8 percent to the applicant pool. While this may seem to be a fairly insignificant number, it must be put in the larger context that at present the success rate of women applicants to the NSF program still lags that of men (12.7 percent of women applicants were named fellows in 1989 compared with 15.1 percent of male applicants), and that fewer than 20 minorities received fellowships from the 850 awarded in the non-targeted part of the program in 1990. Another 150 awards were made to underrepresented minorities through the targeted fellowship effort.

NSF has been working in good faith with the congressionally mandated Committee on Equal Opportunity in Science and Engineering, to increase the participation of women and minorities in its fellowship programs, adding innovations which not only supported the students but which also encouraged the production processes within the pipeline such as through recognizing the baccalaureate colleges and universities of origin of the minority fellows.

Perhaps other mechanisms to promote the flow of under-participating students should also be explored, such as by providing support to GEM (the graduate component of the minorities in engineering effort which has accounted for a disproportionate share of the minority engineering Ph.Ds). Graduate Engineering Degrees for Minorities, Inc., based at Notre Dame, has expanded its graduate recruitment and support activities to include the natural sciences. GEM is a consortium of 60 universities and 71 employer members. Only funding currently limits the ability of GEM to serve even more students. There were insufficient funds for over 100 excellent candidates in the 1990 competition who could not be accommodated. GEM is proactive in its recruitment, with staff visiting campuses, talking directly to students, negotiating directly with universities to encourage applicants, developing tools specifically aimed at answering many of the questions regarding the how, why and what of graduate education for these students.

Adding funds to such an independent effort, which is totally consonant with the NSF program, could enhance the effectiveness of the Foundation's goals in this area and leverage limited federal dollars. GEM started as a program targeting the master's degree in engineering. Over its history 85.5 percent of the GEM Fellows who enrolled in these programs successfully completed their degree requirements.

I offer this idea of investing in GEM as an example of strategies which might be explored by NSF in meeting its goals of increased doctoral output, especially from this hard to serve population. In addition to reducing the need to add staff and associated administrative costs within the Foundation's budget, this strategy has the added advantage of follow-up with the students, something not yet available through the NSF program.

Currently, U.S. citizens are more likely to indicate "personal" as the primary source of support for doctorate recipients for all fields of science than either permanent or temporary resident non-citizens. Smaller percentages of non-citizen permanent residents who received doctorates completed their degrees with debt than U.S. citizens (37.4 percent vs. 54.7 percent of recipients with debt in 1988). Their median level of debt is also slightly lower than that of U.S. citizens.

Particularly disturbing is the fact that a larger share of underrepresented minority doctorate recipients are more likely to report debt (63.3 percent of American Indians, 60.5 percent of Blacks and 66.2 percent of Hispanics compared to 54.1 percent of White citizens and 20.7 percent of non-citizen temporary residents), with the highest median level of debt ($8,283) of any group among Hispanics. There are field differences in debt level, which along with field distribution differences by race, might account for some of the disparity that is seen. For example, the highest levels of indebtedness appear among social science doctorates; among the sciences these fields account for a larger share of doctorates awarded to underrepresented minorities than for other groups.

When women are experiencing lower success rates in the current NSF fellowship program even with modest targeted efforts; when women (and many minorities) are more likely to be indebted and to bear higher median levels of indebtedness; when U.S. citizens are more likely to indicate "personal" as the primary source of support for the doctorate by those who complete the degree; it may send the wrong message at this time to expand the eligibility pool for graduate fellowships.

We must remember that the perspective on debt and indebtedness comes only from completers. We have no way of knowing the extent of the graduate support issue without also looking at non-completers, at differential access to personal support among non-completers, and at the role of inadequate financial resources in the graduate decisionmaking process, especially of minority students.

If one could be assured that adequate appropriation levels would accompany the pool expansion called for in the authorization process, it may be time to look at opening up the eligibility to non-citizen permanent residents to make this program consistent with the Presidential Young Investigators Program. If appropriations do not follow and the expanded eligibility is approved, we may end up worse off than ever in our efforts to expand the pool of women and minorities.

I am suggesting that questions regarding graduate support need to be viewed in a much larger context; that the NSF might be asked to study the larger questions regarding support for graduate education and to develop a coherent strategy that may include fellowships as only one of a possible constellation of graduate support mechanisms.

Issues which might explored in such a review include:

(1) the adequacy of stipend size;

(2) the adequacy of educational cost allowances for institutions;

(3) the cost and benefit of adding research and travel awards to the current fellowships;

(4) the need for a targeted graduate support program for students with disabilities;

(5) a needs assessment for traineeships and their potential for addressing issues such as geographic spread, subfield targeting, interdisciplinary areas of study, and population targeting (Traineeships may give the Foundation a "scalpel instead of an ax" as a tool to help address its human resources concerns);

(6) the additional potential of supporting broad-gauged programs outside of the regular NSF structure;

(7) the current mix of graduate support mechanisms within NSF -- research assistantships and fellowships -- and the extent to which these provide support to different student groups; and

(8) the possibility of providing modest awards to encourage graduate participation among honorable mentions.

Graduate student support strategies must be looked at in their broadest possible context, all the while seeking maximum leverage for federal investment while providing options for students, faculty and institutions alike.

Section 5(e) Associate - Degree - Granting College/University Partnership

The proposed program speaks to concerns about the pipeline for science and engineering, and especially for ensuring a flow of talent from 2-year to 4-year institutions in the areas of mathematics, science, engineering and technology. I totally support the need to explore interventions at this transition point. Minority participation in post-secondary education is disproportionately in 2-year colleges. If you care about affecting the flow of talented minority students into science and engineering at baccalaureate levels and beyond, the leaks from the 2-year colleges must be plugged.

What is not clear is whether the array of activities specified in the proposed legislation addresses the central issues which hamper the most successful transition. While I fully support the intent, I recognize that the specified activities fail to address such structural issues as the incentives of 2-year and 4-year institutions to forge such partnerships. Even if a student would benefit from entering the 4-year institution before completion of the associate degree program, what incentives exist for the 2-year institution to encourage earlier matriculation?

The list of program elements described in the proposed legislation are worthy activities, but they cannot add up to a generic strategy -- a set of interventions to fit every situation, every institution and/or every field.

Again, rather than specify the details of a program to facilitate the 2-year to 4-year institution transition, Congress might direct the Foundation to develop for your consideration and review, a program strategy to address this and other documented leakage points of the S/E pipeline.

Innovative Instructional Technologies

The potential of technologies in science and mathematics instruction for children as well as for adults is often discussed, but the promise of such widespread use has yet to be realized.

NSF as well as the Department of Education have supported such innovative technologies in the past. We need further investment in this area to take advantage of the opportunities for learning which we have every reason to believe would be forthcoming. While I offered testimony in the earlier section regarding my concerns about the specificity and prescriptiveness of Section 5(e), I believe that Section 3 in many ways stops short of suggesting an expanded view of technology in education.

(1) There are strong reasons for arguing that the technologies listed in the draft legislation are limiting in that they exclude telecommunications, leaving out the potential to expand distance learning for disadvantaged rural and urban school settings.

(2) From personal experiences I believe that placing the technology in education issue solely in the context of school use misses the point and an opportunity. The very nature of the technology would easily allow quality education to take place beyond the schoolhouse, including (perhaps especially) in the community.

(3) We must begin to cross over the boundaries and discuss utilization of technology in multiple-purpose sites where children, adults, dropouts, in-school and out-of-school needs are addressed.

At AAAS several years ago we were able through a gift of computers from the Apple Computer Company to establish 56 community computer learning centers. Located in housing projects, a shopping center, churches, in community youth facilities, colleges and schools, these centers, supported by the efforts of various community-based organizations, serve clients from pre-school to senior citizens. They are educational and recreational centers for children and second chance centers for dropouts who are able to complete the GED and develop some workplace skills. Our community computer center partnerships are changing lives. Some centers articulate with local schools, others with local employment services.

Such an expanded view of the role of technology in addressing literacy and numeracy concerns must prevail if we are to really reach and serve disadvantaged populations.

We need to support specific efforts to develop this potential of the technology, but we also need to look for opportunities to incorporate technology into other program objectives. The elementary curriculum developed as the National Geographic KidsNetwork is one example. Interesting uses are being made of such technologies as bar code readers in informal education such as in museum settings. The Bell Atlantic/AAAS Teacher Institute is an example of a teacher in-service program built around technology topics and employing technology to connect the teachers to each other and to their partners, scientists and engineers who are AAAS members.

As you have so correctly recognized by incorporating this section, technology has fantastic potential to affect education, including education in science and mathematics. But its potential for making a difference as an effective tool of education lies in teacher training to use the technology and a supportive environment. Teachers must have access to the technology at home, in their schools and after school. These teachers must become comfortable with the technology. Perhaps the single most effective strategy for promoting that comfort is to develop legislation that supports purchase and home use of computers by educators such as through a one time tax credit.

As you so appropriately note, there are many departments and agencies of the federal government which can and do support learning technology. One can easily conceive that the FCCSET (Federal Coordinating on Council Science, Engineering and Technology) on education can play a key role in assembling the information required in Section 3(d)(1). But other provisions of Section 3(d) may be more difficult for the Office of Science and Technology Policy to carry out given its small staff and rather modest budget. The real expertise on these issues, the "big picture," if you will, resides in an agency of the Congress, that is, the Office of Technology Assessment. Its reports, Power On, Linking for Learning and Educating Scientists and Engineers: Grade School to Grad School, have provided me with a larger context from which to view this issue. Much of what is requested in the "reporting" provisions is duplicative of work which has been done by OTA, where there is excellent staff capacity to address these issues. In addition this seems to overlap some of the responsibilities of entities set up under the education titles of the Trade Bill, such as the Office of Technology Transfer in the Department of Education.

A System of Solutions

We need a system of solutions to address the system of problems we currently face in (1) providing quality mathematics, science and technology education for all students, (2) in maintaining a flow of talent into science and engineering, (3) in expanding the talent base to include women, minorities and people with disabilities, and (4) in promoting public understanding of science and technology. This draft legislation is a good beginning in pointing out critical needs and areas of special concerns and attention. I urge you to work with the Foundation and request that they provide you with a strategic coordinated plan of how they will address the issues in science education within these four large themes. While doing this we must use what we know already; we must put the ideas together, drawing on the knowledge resident in the Congress, in the Executive, in the States and in the field.

Let's use the natural experiments going on in many of the states to get even smarter about what works and the circumstances under which they work. Let's get our system better tuned to capture, analyze, evaluate and disseminate what we know, providing practical, hands-on technical assistance to those who want help with implementation.

A patchwork approach to programming cannot do what we need to have done in science and mathematics education; a system of solutions can.

FOR IMMEDIATE RELEASE:

January 22, 1990

CONTACT:

Anne Monterio	Howard G. Adams	Ted Habarth
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HISTORIC FELLOWSHIP AWARDS FOR GEM

The National Consortium for Graduate Degrees for Minorities in Engineering, (**GEM**), awarded over **$3 million** in graduate fellowships to 225 African American, Puerto Rican, Mexican American and Native American students at its January 19, 1990 selection meeting in San Diego. For the first time, this Consortium of **60** universities and **71** employer members awarded 21 fellowships for Ph.D. studies in engineering and **20** doctoral fellowships for study in physical and natural sciences. In addition, a record 176 minority students received fellowships for Master's degrees in engineering.

Founded in 1976 by 8 employer and 19 university members, more than 800 minority students have completed their Master's degrees in engineering under this unique program for American citizens. More than **85%** of those who have received GEM fellowships over the past **14** years have graduated with their Master's degree, accounting for 10 to 15 percent of the nation's output of minority engineering Master's degree recipients each year.

This year's awards take on even greater significance in light of the country's growing need for graduate talent in the sciences and engineering. Recent reports highlight a growing crisis in the supply of American graduate talent. In 1988, for example, only 259, or 2.3% of the 11,452 doctoral degrees in physical and life sciences went to minority citizens, while foreign nationals accounted for 2,539, or **22.2%** of the total. In engineering the data are even more alarming. While 1,723, or **41.1%**, of the 4,190 1988 engineering Ph.D. degrees went to foreign students, Black students accounted for only 31; Mexican Americans, 11; Puerto Ricans, 13 and Native Americans, 4. (See Summary Report 1988: Doctorate Recipients from United States Universities, National Academy Press, Washington, 1989).

Due the exceptional productivity and growth of this program, the University of Notre Dame provided this Consortium with its own facilities, known as the "GEM Center." From this focal point for Minority Graduate Education, Dr. Howard G. Adams, GEM's Executive Director, led a student search for this year's fellowship awards, an effort that produced a pool of more than 600 minority applicants.

Only funding limitations left many of this year's GEM applicants without fellowships. Because so many of them, well qualified for graduate school in science and engineering, remained without funds for advanced degrees, Dr. Adams continues his efforts to create a national data base to connect such talent to other financial support programs. Another GEM Project, known as **JOURNEY**, attempts to demystify science and engineering among today's teenagers to ensure the adequacy of future pools of GEM applicants.

For more information on GEM, call or write to Dr. Howard G. Adams, Executive Director, The GEM Center, Box 537, Notre Dame, IN 46556

Table K: Mean Percentage of Support for Doctorate Recipients, by Source and Broad Field, 1988

	Field of Doctorate							
Source	All Fields	Phys. Sci.*	Engineering	Life Sci.	Social Sci.	Humanities	Education	Prof/ Other
Federal Total**	10.4	16.8	14.3	20.8	6.1	2.5	2.9	3.5
Research Ass't	5.5	13.7	10.0	8.9	1.7	0.2	0.4	0.4
Fellowship	0.6	1.0	0.8	1.1	0.5	0.1	0.1	0.0
Traineeship	1.9	0.3	0.4	8.3	1.4	0.0	0.1	0.1
Other HHS	0.2	0.0	0.0	0.6	0.3	0.0	0.1	0.2
Title IX-G*POP	0.3	0.3	0.3	0.3	0.4	0.2	0.2	0.3
Other Dept Educ	0.3	0.0	0.1	0.1	0.4	0.8	0.5	0.1
GI Bill	0.5	0.1	0.4	0.2	0.5	0.5	1.0	1.2
Other Fed Suppt	1.2	1.4	2.3	1.3	0.9	0.8	0.7	1.2
University Total	39.2	59.1	52.8	41.8	34.2	42.8	15.5	33.6
Univ Teach Ass't	17.0	28.8	14.5	13.1	16.6	28.1	6.7	17.7
Univ Res Ass't	14.9	24.7	32.2	20.4	9.3	2.6	3.9	8.9
Univ Fellowship	5.2	4.8	4.9	6.2	5.7	9.8	1.8	5.0
Coll Work-Study	0.4	0.2	0.2	0.4	0.6	0.7	0.3	0.2
Other Univ Suppt	1.7	0.7	0.9	1.7	1.9	1.7	2.7	1.7
Personal Total	43.4	17.8	20.8	30.1	55.1	50.3	74.6	55.5
Own Earnings	23.3	7.2	9.9	12.1	25.0	25.5	51.5	31.1
Spouse Earnings	8.6	4.6	3.5	8.5	10.9	11.5	11.1	11.0
Family Contrib	5.2	3.3	5.6	4.5	7.3	6.1	4.4	6.7
Guar Stu Loan	5.3	2.5	1.6	4.4	10.0	5.7	6.4	5.6
NDSL Loan	0.5	0.1	0.1	0.3	1.1	1.0	0.5	0.5
Other Loans	0.5	0.2	0.3	0.3	0.8	0.5	0.8	0.8
Other Total	6.8	6.2	12.0	7.2	4.5	4.3	6.8	7.3
Natl Fellowship	1.1	1.4	1.6	1.0	1.2	1.6	0.4	0.7
Business/Indus	2.2	1.7	4.1	1.3	1.1	0.6	3.9	2.9
Foreign Gov't	2.7	2.5	5.6	4.0	1.6	0.9	1.7	2.3
Other Sources	0.8	0.6	0.7	0.9	0.7	1.2	0.8	1.4

*Includes mathematics and computer sciences.

**Research assistantships include RAs funded by NSF, NIH, and USDA, as well as "other" federal RAs. (RAs funded under federal grants to universities generally fall under "University".) Fellowships represent those funded by NSF and USDA. Traineeships are from NIH. Federal programs such as GSL and NDSL are not included under federal, but appear under "Personal."

TABLE L: Percentage Distribution of Primary Sources of Support for Doctorate Recipients, by Demographic Group, 1988*

				U.S.	Perm.	Temp.	U.S. Citizens				
Source of Support	Total	Men	Women	Citiz.	Res.	Res.	Am. Ind.	Asian	Black	Hisp.	White
Total All Fields											
Personal	41.8	35.5	53.3	49.0	33.7	15.6	59.0	36.0	59.7	46.4	49.1
University	39.4	43.0	32.9	34.7	50.8	55.2	19.3	40.1	24.1	30.7	35.0
Federal	11.6	13.0	9.0	12.2	7.2	10.1	14.5	18.9	10.3	17.1	12.0
Other	7.2	8.5	4.8	4.1	8.3	19.1	7.2	5.1	5.9	5.8	3.9
Physical Sciences**											
Personal	14.2	14.4	13.0	17.9	12.9	5.8	44.4	15.0	6.7	13.1	18.2
University	60.6	60.2	62.7	56.8	66.8	68.2	33.3	59.0	56.7	45.9	56.7
Federal	19.2	19.2	19.0	21.3	13.4	15.1	22.2	21.0	20.0	32.8	21.2
Other	6.1	6.3	5.3	4.0	6.9	10.8	0.0	5.0	16.7	8.2	3.9
Engineering											
Personal	15.8	16.3	9.5	20.0	20.5	10.3	25.0	21.6	17.6	17.9	19.8
University	54.8	54.7	56.6	47.9	61.7	61.1	25.0	54.4	35.3	43.6	47.6
Federal	16.3	15.8	21.9	20.9	10.4	12.4	25.0	14.4	17.6	30.8	21.3
Other	13.1	13.2	12.0	11.1	7.5	16.3	25.0	9.6	29.4	7.7	11.3
Life Sciences											
Personal	25.7	23.0	30.3	28.9	25.4	11.7	46.7	26.1	28.1	23.1	29.2
University	42.7	44.0	40.3	41.1	48.1	48.1	33.3	27.7	34.4	47.4	41.4
Federal	23.8	23.6	24.0	27.5	12.7	10.7	20.0	43.7	31.3	29.5	26.9
Other	7.9	9.3	5.4	2.5	13.8	29.5	0.0	2.5	6.3	0.0	2.5
Social Sciences											
Personal	55.7	51.5	60.8	60.7	52.1	25.0	70.0	51.4	58.5	57.5	61.1
University	33.3	36.5	29.5	30.2	40.6	51.4	0.0	37.1	25.9	19.2	30.7
Federal	6.1	6.2	6.0	6.7	1.0	3.8	10.0	7.1	12.6	15.8	6.1
Other	4.8	5.8	3.6	2.3	6.3	19.8	20.0	4.3	3.0	7.5	2.0
Humanities											
Personal	49.2	49.3	49.0	52.3	41.0	26.5	80.0	44.8	42.9	50.0	52.6
University	44.8	43.9	45.8	43.1	51.8	56.1	20.0	48.3	38.1	41.7	43.3
Federal	2.3	2.9	1.6	2.2	0.7	3.4	0.0	3.4	6.3	4.2	2.0
Other	3.8	3.8	3.7	2.4	6.5	13.9	0.0	3.4	12.7	4.2	2.0
Education											
Personal	76.5	75.5	77.4	79.5	71.3	42.8	65.7	83.6	78.1	70.4	80.0
University	13.4	11.1	15.4	12.8	18.9	19.0	14.3	10.4	15.7	15.6	12.5
Federal	3.0	3.9	2.2	2.9	1.4	5.3	11.4	3.0	3.1	8.9	2.6
Other	7.1	9.6	5.0	4.9	8.4	32.9	8.6	3.0	3.1	5.2	4.9
Professional/Other											
Personal	53.7	51.6	58.2	61.9	40.5	27.4	60.0	58.3	53.7	56.3	62.6
University	33.7	33.6	34.0	27.8	53.4	49.1	20.0	29.2	20.9	25.0	28.1
Federal	3.7	3.9	3.3	4.5	0.0	2.1	20.0	8.3	17.9	0.0	3.7
Other	8.9	10.9	4.5	5.8	6.0	21.5	0.0	4.2	7.5	18.8	5.6

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*A recipient's "primary" source of support is the source with the largest reported percentage. "Personal" includes loans as well as own earnings and contributions from the spouse/family. "Other" includes U.S. nationally competitive fellowships, business/employer funds, foreign government, and other nonspecified sources.

**Includes mathematics and computer sciences.

TABLE M: Percentage of Doctorate Recipients with Debt and Median Level of Debt, by Demographic Group, 1988

	Percent With Debt	Median Dollars*
All Ph.D.s	47.1	7,471
Men	46.9	7,258
Women	47.4	7,869
U.S. Citizens	54.7	7,649
Permanent Residents	37.4	7,391
Temporary Residents	20.7	5,470
U.S. Citizens		
American Indians	63.3	7,116
Asians	53.0	7,748
Blacks	60.5	7,655
Hispanics	66.2	8,283
Whites	54.1	7,616

*Doctorate recipients who reported no debt are not included.

Letter of Transmittal Executive Director

To Members of the GEM Board of Directors

Dear Directors:

It is a distinct privilege to present, on behalf of the staff, the 1990 GEM Annual Report for the Fiscal Year July 1, 1989 - June 30, 1990.

Given the excellent results that GEM experienced in all phases of its operations, there is good reason to be extremely pleased with the contents of this year's report. Because of these accomplishments, 1990 can be termed a "BANNER YEAR."

In this report we will review various programmatic operations and present our financial summary. The purpose of this transmittal letter is to highlight some of our major accomplishments and to offer you a prospective on challenges that lie ahead.

- *Established the GEM CENTER for Graduate Education for Minorities on September 1, 1989.*

- *Secured through the University of Notre Dame, a new facility to house the GEM CENTER without cost to the Consortium.*

- *Initiated three new programs:*
  The GEM Ph.D. Engineering Fellowship Program, The GEM Ph.D. Science Fellowship Program, The Nationwide Data-Base Clearinghouse

- *Held a successful draft where 228 new GEM Fellows were selected:*
  187 M.S. Engineering Fellows; 21 Ph.D. Engineering Fellows; and 20 Ph.D. Science Fellows. NOTE: The total value of the 1990 awards from GEM funds is approximately 9 million dollars.

- *Recorded four new professors among our alumni:*
  - *Dr. Christine Grant - School of Engineering Faculty, North Carolina State University.*
  - *Dr. Theda Daniel-Race - School of Engineering Faculty, Duke University.*
  - *Dr. Gerson Beauchamp - School of Engineering Faculty, University of Puerto Rico.*
  - *Dr. Andrew Meade - School of Engineering Faculty, Rice University.*

- *Secured three major equipment grants for the GEM CENTER:*
  Computer equipment to automate the CENTER and establish the data base, from IBM Corporation and Apple Computer Company. Copier from Eastman Kodak.

- *Secured four major financial grants:*
  $400,000 for the CENTER from the Lilly Endowment Fund. $300,000 for the Ph.D. Engineering Program from IBM Corporation. $300,000 for the Ph.D. Engineering Program from General Electric Foundation. $100,000 challenge grant for the Data-Base from NSF.

- *Added eight new employer sponsors:*
  Apple Computer Inc.; The BFGoodrich Company; Colgate-

Palmolive Company; Intel Corporation; Martin Marietta Corporation; Penn State/Applied Research Laboratory; Oak Ridge Laboratory; and Sandia National Laboratory. (Oak Ridge and Sandia are former sponsors who returned to membership.)

- *Had four employers increase their participation through multiple sponsorships:*
  General Electric, (4); Motorola, (2); Dow Chemical, (2); and The Aerospace Corporation (2).

- *Received acceptances from five universities invited to membership in the Masters of Engineering Program by the Board:*
  University of Cincinnati; University of Colorado, Boulder; University of Minnesota; Vanderbilt University; and Virginia Polytechnic Institute & State University.

- *Initiated the Ph.D. Science component with a charter group of eleven employer and twenty-one university sponsors:*
  Employers - Baxter Healthcare Corporation; Corning, Incorporated; Dow Chemical Company; E.I. duPont de Nemours & Company; Eastman Kodak Company; Eli Lilly Company; Merck & Co., Inc.; Procter & Gamble Company; Rohm & Haas Company; 3M Company; and Union Carbide Corporation. Universities - California Institute of Technology; Cornell University; Columbia University; Georgia Institute of Technology; Harvard University; Michigan State University; Northwestern University; Princeton University; Stanford University; University of California, Berkeley; University of Chicago; University of Illinois, Urbana; University of Michigan; University of Minnesota; University of Texas at Austin; University of Wisconsin, Madison; Vanderbilt University; University of Virginia; Virginia Polytechnic Inst. & State University; Washington University, St. Louis; and Yale University.

- *Employed on the professional staff, Dr. Deborah E. Jackson as Coordinator, Ph.D. Programs, and Robert I. Lewis, II, as Coordinator, Research & Information Systems.*

Despite these significant developments, a number of challenges exist that demand attention: 1) the lack of funds that would permit GEM to support many more worthy applicants; 2) our inability to gain active support from some University Members - they produce no applications, enroll no students, and fail to attend meetings - WE QUESTION THEIR COMMITMENT or REASON FOR MAINTAINING MEMBERSHIP; 3) how to encourage more university members to provide the supportive environment - mentoring, facilities, collegiality, research opportunities, etc. - necessary for success in graduate school; and 4) how to educate the American public on the value of spending resources on the education of minorities —it's in the best interest of the nation.

Although these are major challenges, we are more convinced than ever that with our new initiatives, GEM is in a favorable position to help the nation address the continuing problem of the underrepresentation of ethnic minorities in graduate engineering and science populations.

We are very appreciative for the commitment of time, energy and resources contributed to GEM by our sponsors and friends. We are especially indebted to the officers, Executive Committee and Board of Directors — individually and collectively — for their continued support. A special thanks to the University of Notre Dame for all it does for GEM as our headquarters' sponsor. Because of all of the efforts of so many:

1990 Was a Great Year!
1991 Will Be Even Greater!

Sincerely,

Howard G Adams

Howard G. Adams
Executive Director

Table I

PROFILE OF [redacted] STUDENTS SELECTED AS GEM FELLOWS, [redacted].

Ethnicity and Sex

	Male	Female	[redacted]	Percent
American Indian	2	0	2	1.1%
Black American	79	43	122	65.2%
Mexican American	31	10	41	21.9%
Puerto Rican	17	5	22	11.8%
Totals	129	58	[redacted]	100.0%
	PERCENTAGE	[redacted] 31%		

Class Year

	Numbers	Percent
Juniors	51	27%
Seniors	111	59%
Graduates	25	14%
Totals	187	100.0%

Engineering Disciplines

	Numbers	Percent
Electrical	65	35%
Mechanical	40	21%
Chemical	31	17%
Computer Science	22	11%
Industrial	9	5%
Civil	9	5%
Aerospace	4	2%
Others	7	4%
Totals	187	100%

Schools With Three or More Fellows Chosen

MIT	12	R.P.I.	5	Cal Poly	3
Howard	12	Purdue	5	U.C. Berkeley	3
Tuskegee	10	U. TX at El Paso	5	Southern	3
U. PR	8	Michigan St.	4	Stanford	3
Georgia Tech	8	U. Tennessee	4	Cornell	3
NC A&T St.	7	Prairie View	4	U. Illinois	3
New Mexico St.	6	U. Delaware	3	U.C. Santa Barb.	3
U. Michigan	5				

Overall GPA for Class = 3.35
Fellows from GEM Member Schools = 145 (78%)
Fellows from HBCU's = 40 (22%)

Table II

PROFILE O[redacted] STUDENTS SELECTED AS GEM FELLOWS, 1990

[redacted]

Ethnicity and Sex

	Male	*Female*	*Total*	*Percent*
American Indian	1	1	2	9.5%
Black American	6	6	12	57.1%
Mexican American	3	1	4	19.1%
Puerto Rican	2	1	3	14.3%
Totals	12	9	[redacted]	100.0%

PERCENTAGE FEMAL[redacted]

Class Year

Status	*Numbers*	*Percent*
M.S. Cand.	13	61.9%
Post M.S.	8	38.1%
	21	100.0%

Disciplines

	Number	*Percent*
Electrical	8	38.1%
Mechanical	5	23.8%
Chemical	2	9.5%
Computer Science	2	9.5%
Industrial	3	14.3%
Biomedical	1	4.8%
Totals	21	100.0%

Overall GPA , Engineering: 3.57

[redacted]

Ethnicity and Sex

	Male	*Female*	*Total*	*Percent*
American Indian	1	0	1	5%
Black American	5	10	15	75%
Mexican American	1	0	1	5%
Puerto Rican	0	3	3	15%
Totals	7	13	[redacted]	100%

PERCENTAGE [redacted]

Class Year

Status	*Numbers*	*Percent*
Juniors	1	5%
Seniors	13	65%
Graduates	6	30%
Totals	20	100%

Disciplines

	Number	*Percent*
Chemistry	9	45%
Life Sciences	6	30%
Physics	5	25%
Total	20	100%

Overall GPA , Science: 3.49

PH.D. ENGINEERING FELLOWSHIP AWARDEES - 1990

FELLOW	INSTITUTION	STATE	AREA OF STUDY
COGER, Robin N.	U.C. Berkeley	CA	Mechanical
CRAIG, Walter	Southern Univ.	LA	Industrial
CRUMPTON, Lesia L.	Texas A&M	TX	Industrial
DEL CASTILLO, Hector	U. TX, El Paso	TX	Electrical
DRAYTON, Marcus K.	Univ. Michigan	MI	Mechanical
ETIENNE, William J.	Cal. St., Chico	CA	Computer
FRANKLIN, Rhonda R.	Univ. Michigan	MI	Electrical
GONZALEZ, Roger V.	Univ. TX, Austin	TX	Biomedical
HANSON, Mark L.	Univ. Michigan	MI	Mechanical
JIRON, Cecilia	Univ. Arizona	AZ	Electrical
JOHNSON, Jesse	Stanford	CA	Systems
MITCHELL, Gregory	USC	CA	Electrical
MONTOYA, Lupita D.	Cal. St. Northridge	CA	Mechanical
MOORE, Victor	Univ. Washington	WA	Electrical
NORTE, Andrew D.	Univ. TX, El Paso	TX	Electrical
OCHOA, Sergio I.	Univ. Illinois	IL	Industrial
PADGETT, Darryl V.	Tuskegee	AL	Electrical
RAMIREZ-VICK, Jaime	Univ. Puerto Rico	PR	Chemical
SALICETI-PIAZZA, L.	Univ. Puerto Rico	PR	Chemical
SEDA-POULIN, Marta	M.I.T.	MA	Electrical
YARBROUGH, Walthea V.	NC A&T State	NC	Industrial
ZIYAD, Nigel A.	Univ. Virginia	VA	Electrical

PH.D. SCIENCE FELLOWSHIP AWARDEES - 1990

FELLOW	INSTITUTION	STATE	AREA OF STUDY
BLOOM, Shemal D.	Xavier	LA	Chemistry
BOWIE, Jason L.	U. Illinois	IL	Physics
BROWN, Kenneth B.	Georgia Tech	GA	Physics
CARTER, Kevin	Tuskegee	AL	Chemistry
CASILLAS, Sandra	U. Puerto Rico	PR	Chemistry
CRAWFORD, Mary A.	Knox College	IL	Chemistry
GREEN, Shermalyn R.	North Carolina St.	NC	Microbiology
HARMON, Leslie G.	Tougaloo College	MS	Cellular Bio.
JOHNSON, Casonya M.	Morgan State	MD	Cellular Bio.
JONES, Jeanette	Jackson State	MS	Chemistry
JORDAN, Jacqueline	Univ. Tennessee	TN	Toxicology
KANIPES, Margaret I.	N. Carolina A&T	NC	Biochemistry
KENNEDY, John G.	U. Minnesota	MN	Physics
McADORY, Brenda	Clark Atlanta	GA	Chemistry
McMAHON, DeAwna	Clark Atlanta	GA	Chemistry
FOWDRILL, Joyce	Jackson State	MS	Microbiology
STINSON, Antwuan T.	Alabama A&M	AL	Chemistry
WILLIAMS, Quinton L.	Jackson State	MS	Optics

The GEM Center

Howard G. Adams - Executive Director
Ettore A. Peretti - Associate Director, Administration
Linda I. Wells - Associate Director, Programs

PROGRAM COMPONENTS	FUNDING SOURCES	AWARDS	ELIGIBILITY	PROGRAM/SERVICES OFFERED
GEM M.S. Engineering Fellowship Program Established in 1978 Application Deadline - December 1, Annually CONTACT: Linda I. Wells (219)-287-1097	Employer Contributions University Tuition/Stipend Supplements Donations Grants/Contracts	Stipend $6,000 (per academic year) Tuition and Fees Paid Summer Internship	Minimum Junior Status in Engineering Discipline American Citizenship Ethnic Minority: Amer. Black, Amer. Indian, Mex. Amer., Puerto Rican Credentials Worthy of Admission to GEM Univ. Member Graduate Schools	Workshops for Target Audience Technical Assistance Video Tapes Printed Handout Counseling Materials
GEM PhD Science Fellowship Program Established in 1989 Application Deadline - December 1, Annually CONTACT: Deborah E. Jackson (219) 287-1488	Employer Contributions University Tuition/Stipend Supplements Donations Grants/Contracts	Stipend $12,000 (per calendar year) Tuition and Fees Paid Summer Internship	Minimum Junior Status in Science Discipline American Citizenship Ethnic Minority: Amer. Black, Amer. Indian, Mex. Amer., Puerto Rican Credentials Worthy of Admission to GEM Univ. Member Graduate Schools	Workshops for Target Audience Technical Assistance Printed Handout Counseling Materials
GEM PhD Engineering Fellowship Program Established in 1989 Application Deadline - December 1, Annually CONTACT: Deborah E. Jackson (219) 287-1488	Grants/Contracts University Tuition/Stipend Supplements Donations	Stipend $12,000 (per calendar year) Tuition and Fees	Post M.S. Status American Citizenship Ethnic Minority: Amer. Black, Amer. Indian, Mex. Amer., Puerto Rican Credentials Worthy of Admission to GEM Univ. Member Graduate Schools	Workshops for Target Audience Technical Assistance Video Tapes Printed Handout Counseling Materials
Data-Base Clearing-house/Research Unit Established in 1989 CONTACT: Robert I. Lewis, II (219) 287-1486	Grants/Contracts Users' Fees Memberships	N/A	N/A	Applicant Files Fellowship/Program Source Referrals Modem
JOURNEY Project Established in 1986 CONTACT: Theodore (Ted) Harbarth (301) 953-5382	Grants/Contracts Spot Advertisements Video Tape Sales Educational Materials Sales	N/A	N/A	Video Tapes Counseling Materials

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Mr. VALENTINE. Thank you, Doctor.

In your prepared remarks, you stated that only one of seven students applying to NSF for a graduate fellowship is successful. Is that an argument for increasing funding, or could we imply from that six out of the seven were not qualified?

Dr. MALCOM. I don't think that we can imply from that that six out of the seven were not qualified. There are many more qualified people who come through that program. They have had a tradition within the Foundation of listing the honorable mentions, people who are very well qualified but for whom funding is not available. In that particular case, those people often are considered for funding by colleges or universities.

A lot of institutions look at that as a kind of a talent scout list and go after those people because they know that they have gone through the rigorous screening process and that they are highly qualified. I think that it is an argument for increasing the funds that might be available, but the context in which this was addressed was the question of expanding the eligibility pool.

Mr. VALENTINE. Is that information, Dr. Malcom, that you just talked about readily available? Is it published? Is it easy to get it? I mean, could I go somewhere and pick it up or write a letter and get information as to all the people who applied for an NSF graduate fellowship and who won——

Dr. MALCOM. Who were honorable mentions?

Mr. VALENTINE. Yes. Who won and who was honorable mention. It wouldn't mention the names of all those who applied, would it?

Dr. MALCOM. No, it would not include all those who applied. It included those who applied and went through the selection process and were judged meritorious but for whom funding was not available. That information is usually released in the press release that goes with the issuance of the list of fellows from the National Science Foundation, so it is fairly easy for the institutions to come by that information, and the Foundation in the past has made it a practice to try to publicize that information so that it would serve that kind of a function of talent identification.

Mr. VALENTINE. I have just one more question, and then I'll yield to my colleagues. The indebtedness figures which were mentioned in your written testimony, the figures that you cite for doctoral recipients, does that include only individuals pursuing science and engineering degrees or not?

Dr. MALCOM. Some of the indebtedness figures include all doctorates. Some of the indebtedness figures are particular to particular fields within science and engineering, and I think that different fields have different frequencies of high debt. People who go in engineering, for example, have the lowest indebtedness. The people in the social sciences have the highest indebtedness.

So there are differences with regard to particular fields. But these data came from the summary of doctorate recipients in 1988 from the National Research Council, and I am sure that they would be able to give the very, very fine level breakdown by field and by all the other kinds of demographics that you might want to look at.

Mr. VALENTINE. You're talking here not about grants but about loans to students?

Dr. Malcom. That's right.

Mr. Valentine. Do you have any information that you can share with us as to the percentage of that money that's repaid and over what period of time?

Dr. Malcom. No, I do not.

Mr. Valentine. Is that information available?

Dr. Malcom. I do not know if it is, but I think that the National Research Council might have some further data on this particular topic.

Mr. Valentine. Mr. Boehlert?

Mr. Boehlert. Your whole testimony is quite interesting and very much to the point. I'm particularly intrigued by a question you have on page three. You pose the question "what proportion of wages which could be commanded by the students if they entered the work force directly would need to be offered to students to get them to consider graduate education in lieu of direct entry into the job market?"

While you're thinking of an answer, let me give you—it's a very difficult question, because I know what happens. The typical outstanding student graduating from college, wanting nothing more than to continue education, says, well, I've got about $15,000 or $20,000 in debt right now, I've got an attractive job offer down the street, and I want to get married and start a family, and what's in it for me? What is the magic figure? How do we do it?

Dr. Malcom. I wish I knew what the magic figures were. One of the problems is that I think that when we go into graduate education—when I made the decision to go to graduate school rather than go into the work force, I knew that I was giving up making money right then, but that didn't matter. I mean, you don't do that because of money. You do it because of a love of the field, but sometimes money can make it difficult for you to pursue that love of the field.

Mr. Boehlert. Most often make it impossible to do that.

Dr. Malcom. Make it impossible. That's true. Part of the problem is that the graduate school option tends not to be presented to people so that you actually are recruiting on a level playing field. Often times you don't have people encouraging or out there recruiting, just like the big corporations will send recruiters to the placement office. We don't have graduate schools sending recruiters to the placement office to say, come and go here; we know that it's going to be a problem.

But I think that we need to look at questions such as, do we need to take on a strategy of forgiveness, for example, that, if people decide to go on and pursue the graduate degree, that we would forgive the debt perhaps in some proportion that they may have incurred during their undergraduate years. I think that the whole kind of array of strategies that might help to address some of the impediments—it is a barrier—but there's the need to look at this as a possible strategy for helping to remove that barrier.

Mr. Boehlert. Can you discuss a bit more why you seek traineeships as a useful alternative to fellowships?

Dr. Malcom. I know I used the expression in there that it gives you a scalpel rather than an axe as a tool. I think that one of the things about traineeships that I like is the fact that it allows one to get not only individual support for the money, but also to be able to affect what happens within institutions.

If you wanted, for example, to encourage a particular field—say that you decided suddenly that you needed people to come out in manufacturing engineering—then you could, in fact, target traineeships in that particular area as a way of attracting and drawing the people to a particular institution. That institution might then be able to set up supportive mechanisms that would build a large enough mass of people so that the other kinds of impediments to getting through smoothly might be addressed at the same time that we are addressing the issue of graduate student support. So that it helps to support the environment that is supportive of getting the students out of the system at the same time that it helps to support the institution capacity. I'm not saying that that is the only thing that ought to be used. I would argue that there needs to be increased support for fellowships as well, but I think that the problem is that we have had traineeships out of the mix of support strategies that were available to us and that we need to reconsider putting traineeships back into the mix.

Mr. **Boehlert**. In addition to?

Dr. **Malcom**. In addition to fellowships and research assistantships. But maybe what we need to look at—and that's why I argued for some work within NSF to look at this—is what is the mix? Do we currently have the right proportion of research assistantships? Do we have too many? Might we instead turn some of that into the traineeship mold?

Mr. **Boehlert**. You've got a lot of great questions. Have you got any good answers?

Dr. **Malcom**. Well, I don't have the answer to that, but I think that in that particular case that NSF needs to look at those particular questions and ask itself those answers in the context of a larger research agenda than it has, because that's really what we're talking about.

Mr. **Valentine**. We've got all the answers.

Mr. Brown, would you like to go ahead now? We've got a vote in 10 minutes.

Mr. **Brown**. I think we ought to go vote.

Mr. **Valentine**. I think so, too.

These bells mean that we have to perform an unfortunate task. We have to go vote, and we'll be back in about 10 or 15 minutes, so if you can just bear with us.

[Recess.]

Mr. **Valentine**. Mr. Brown?

Mr. **Brown**. Thank you, Mr. Chairman.

Dr. Malcom, I think that we're reaching a wide public perception of our failure as a Nation to fully develop our human resource pool, particularly in science and engineering, and I want to just ask you in connection with your work at AAAS if you feel that we have an adequate statistical or indicator base in order to measure and compare both the trends over time and the comparisons between our Nation and other nations or internal comparisons within the Nation and so forth.

Does the AAAS make an effort to do that? Do you relate to and work with the NSF in the development of their science indicators, and are they adequate fully for this purpose?

Dr. **Malcom**. The AAAS uses, I guess, as its human resources analysis the Commission on Professionals in Science and Technology, where we are one of the supporting members. They are a cooperating institution of AAAS, so that a lot of that kind of analytical work we rely on CPST to do. And we basically look—and they utilize the NSF, Department of Education, and other data in order to try to make sense out of the trends that are out there.

I think that we are getting to a point where we really can better understand the flow of people through the system. I do not think that we yet have good tools to understand how much people really know, how much they understand, about science and about mathematics. I feel that there has been an underinvestment in assessment tools and that—for that reason, we are limited to particular kinds of tests in order to really get any kind of indication of what children in the United States know and are able to do.

Some headway is being made in the whole question of assessment within the States, for example. There is a major assessment project going on in California, but it is not clear that there is adequate documentation of that process of building an assessment in California or that there is any way for the people in California to connect to the people in Connecticut, who are also working independently on assessment issues, or if there is any investment from the Foundation or anyone else in making sure that the lessons that are learned in one place or another can extend to the entire country.

Yes, we are underinvesting in the kinds of tools that we need to build better indicators about what our children know and are able to do.

Mr. **Brown**. We do occasionally see, perhaps only anecdotal, references to the level of performance of various grade levels in math and in science and geography and things of that sort. Is that an indication that there is inadequate, shall we say, international assessment base so that we can make the comparisons between what our students are doing with what those in Bulgaria or Japan or something like that?

Dr. **Malcom**. I don't think that there is yet an adequate base to even do that. There have been some improvements, some real strides, in the way that we look at those issues internationally. The introduction, for example, of the concept within the international area, which I think is important domestically as well, introduction of the whole concept of opportunity to learn. Have you even been exposed to the material before you then go on to look and see how well the students know what it is that you're asking him about?

Mr. **Brown**. Mr. Chairman, would you like to go vote and I'll continue here for 10 minutes or so, and then I'll go vote?

Mr. **Valentine**. I think that's a good idea.

Mr. **Brown**. We'll keep this continuing.

Mr. **Valentine**. That's an excellent idea. I'll do that.

Mr. **Brown**. Okay.

Continuing along that line, I have recently had cause to examine the NSF indicators in some detail, dealing with, for example, the number of engineers per 10,000 in the working population, the number of scientists, and the comparisons between the United States, Japan, and the EC nations, in which it appears that over time we're seeing them fairly rapidly overtake us, as measured by these indicators.

Then you look at other kinds of indicators, like total investment in research and development in these various different countries measured as a percent of GNP, and you see a remarkable correlation. The investment by European industrialized nations and Japan shows a steady growth rate in investment in research and development. Ours is flat and, actually, today I think it a tenth of a percentage point less than it was 25 years ago in terms of overall national investment in R&D measured as a percent of GNP.

Now, do you consider these kinds of indicators to be significant from the standpoint of trying to analyze from a policy perspective why we are not getting a better production of scientists and engineers?

Dr. **Malcom**. I think that those are important indicators, especially the whole notion about how many engineers or scientists per capita we have compared to other countries. But I think that the other particular indicator that would basically be needed would be the disaggregated issue of the mix of fields.

To what extent are we investing, for example, in manufacturing engineers? In process engineering? In the kinds of things that will allow us to go from basic research to an actual product? There are lots of steps that are in between that, and the whole question about not only the gross number of engineers, but in which fields those engineers happen to be, I think, is really a critical kind of issue.

In a like manner, the whole issue of percent of Gross National Product that goes toward R&D, one would have to say what R and what D? Because if it includes, for example, defense development, that could distort the picture in terms of the amount of effort that is going toward research and development that is likely to end up as products that are available for trading on the international markets.

Mr. **Brown**. Well, the NSF indicators do have a breakdown by military and civilian R&D, and it's extremely useful, particularly when you compare it with the situation in these other countries where there's a far greater preponderance of civilian R&D than there is military R&D.

Now, do we have any adequate base that will allow us to compare the way in which we support students in science and technology at the university and post-graduate level? Here in my packet, there is some data from GEM, the consortium for graduate degrees for minorities in engineering, indicating the way in which they are supported—personal, fellowships, traineeships, spouse, family, so forth—and it's a mixed bag in this country.

I'm totally ignorant of how, for example, a promising German student would be supported as he moves up the line or a promising Japanese student. Do we have data on that kind of situation?

Dr. **Malcom**. I am not sure. I know that the National Science Foundation has been interested in increasing its capacity to look at international indicators. I sit on the Advisory Committee for the STIA Directorate, and there was a report at the last meeting about the need within the science resources studies unit to look at developing on the international side a better sense of what our competitors and allies and friends and foes and what the rest of the countries in the world are doing with regard to a lot of different indices, not just the ones that we have mentioned. But I'm not sure about that particular one.

Mr. **Brown**. Well, I have seen some indicators coming out of the European community. They're rather vague in my mind, but I assume they must be trying to make some kind of a coordinated analysis within the European community, and probably Japan does an even better job.

I had occasion a year or so ago to participate in a Science Education Conference at Berkeley sponsored by Admiral Watkins and Glen Seaborg at Lawrence Laboratory there, and it was a very good conference, I felt, addressing the problem we're talking about here. And one of the highlights was an after dinner speech by the president of a black college in Florida, describing how they handle the recruitment and treatment of promising black students.

Effectively, what he described was a system in which they went out and positively selected promising high school students and made a contract with them. You come in here, work hard, get your degree, and we contract to do the following: We'll provide you with support while you're in school, a summer job with a potential employer, and a contract to be hired by the employer when you graduate. And if you show promise for graduate work, we'll give you a similar kind of contract.

He was very impressive and aggressive, I might say. He goes around then to the conscious-stricken corporations and says: "you want minority engineers and scientists, I guarantee you, you name the field and tell me what you're willing to do; and we'll produce them for you." And he described how he went to the insurance industry, for example, and said, "look, you don't have any black actuaries. You want some black actuaries? Here's what you have to do, and I'll deliver them to you."

He performed. It worked. But it was based upon the assurance to the student: If you work hard, you'll get your reward; and it won't be in heaven; it will be right here on earth. And we don't seem to have much of that in terms of recruiting and maintaining promising students, regardless of race or sex.

Dr. **Malcom**. That's true. One of the things that I think has been really in a lot of ways, kind of disheartening is that when you look at the undergraduate system, a student comes in basically, and they enter a process of weeding out. It seems as though people are saying that a certain number of you probably don't belong here, and therefore we will make sure that we find out who you are as soon as we can, rather than saying that we need to cultivate you. You may be coming here with deficiencies, but we're going to make it so that you can make it through the system.

There's a program that's a little bit closer to home at the University of Maryland, Baltimore County, that similarly has made such a contract, a commitment, to, in this particular case of this program last year, around 20 young, black men and basically have guaranteed them a full tuition, full scholarship, in science or engineering. They had to go into a science-based field, and they had to indicate that they had as their degree goal either the Ph.D. or the M.D. degree. And that program is up and running at the University of Maryland, Baltimore County.

But you're right. I mean, we don't see that kind of thing. Part of the GEM success has been the fact that students were identified; they were guaranteed support to get them through the system; they were identified early enough; they were given the kinds of experiences that would allow them to see what they would do within their career, what their future would look like. And I think that more of those kinds of programs would be needed so that students don't have to operate totally on faith.

Mr. BROWN. You can identify the potential much earlier than a freshman in college. You can identify it almost in elementary school, and you need to nurture that. Your remark about the competition and the weeding out reminds me, and I shouldn't reveal age by talking about things like this, but 40 or so years ago, I went to an institution we jocularly called Benning School for Boys. It was infantry officer training. And I remember very well they said, look at the person on each side of you, because they'll both be gone when you get through. In other words, two-thirds were weeded out. And that may be good for infantry officers, but it isn't good for science trainees.

I'm going to recognize Mr. Buechner, and he's going to carry on while I go vote. And the chairman will be back shortly.

Dr. MALCOM. Okay.

Mr. BUECHNER. Doctor, it is a rare occasion in which a Republican minority member gets to chair this. I'm going to declare this bill passed. [Laughter.]

Doctor, that's all I really have. We can start with the next panel, I guess, so thank you very much.

Dr. MALCOM. OK. Thank you.

Mr. BUECHNER. The second panel is Dr. Dennis Wint, Dr. Thomas Krakauer, Mr. Roy Shafer, and Ms. Ilma Levine.

Exercising the prerogative of the chair, I'd certainly like to take this opportunity to welcome Dr. Dennis Wint, in particular, who is a neighbor of mine. He joined the St. Louis Center as President in 1986 in the St. Louis Metropolitan area. He's chairman of the Regional Commerce and Growth Association Museums and Performing Arts Committee—and I got your letter on the NEA the other day, Dennis—he is the Vice President of the St. Louis Museums Collaborative, he's a member of the Accreditation Commission for the American Association of Museums, Vice President and Chairman of the Legislative Committee of the Association of Science and Technology Centers, and has been appointed to the National Science Foundation Advisory Committee to the Directorate for Science and Engineering Education.

He earned his Ph.D. degree in Curriculum and Instruction from Case Western University in Cleveland, Ohio, and his Bachelor of Science degree in Wildlife Management from the University of Michigan, Ann Arbor. Prior to joining St. Louis Center, he was the Director of Cranbrook Institute of Science in Bloomfield Hills, Michigan—that's a beautiful place, I've been there, but not as nice as the one we're going to have in St. Louis—and he was also Director of the Museum and Vice President of the Academy of National Sciences in Philadelphia, Pennsylvania.

Since I am the chairman right now, I would like to welcome Dr. Wint here today. Welcome goes to all of you. If you would begin with your statements, I would ask each of you that if you have prepared remarks, please submit them for the record and try to synthesize them as much as possible. That way, we can make sure that all the testimony gets in and that all the questions can be answered.

Here come the two real important people now, but, Dr. Wint, would you begin? Thank you.

STATEMENT OF DR. DENNIS M. WINT, VICE PRESIDENT, ASSOCIATION OF SCIENCE-TECHNOLOGY CENTERS, WASHINGTON, DC, AND PRESIDENT, ST. LOUIS SCIENCE CENTER, ST. LOUIS, MO

Dr. **Wint**. Thank you very much, Mr. Buechner, and members of the committee. I'm pleased to have this opportunity to speak before you this afternoon concerning the Science and Technology Education Act of 1990, and particularly section 4 as it relates to informal science education.

As Vice President for the Association of Science-Technology Centers, known as ASTC, I am representing 195 member institutions in the United States and another 58 in countries around the world.

You are well aware of the issues that are facing this Nation and our community in terms of the underachievement of students in science and technology. It is now time for a concerted effort at the Federal, State and local levels to improve our educational programs and student performance.

Learning does not begin at 8:00 in the morning and end at 3:00 in the afternoon for the 180 days designed as the school year nor is science literacy achieved in the 18 to 20 minutes that we spend per day in the elementary school classroom. Learning opportunities are pervasive throughout society. Science museums and educational television reach millions of people annually with science, mathematics, engineering, computers, the environment and technology.

Science museums are among the most popular educational institutions in our society. Over 75 million visitors annually attend science museum programs. At the St. Louis Science Center, the number of visitors has increased from 275,000 in 1985 to 886,000 in 1989, as a result of our new programs and hands-on exhibitions. And we're expecting almost 2 million visitors by 1990.

In 1989, the Boston Museum of Science had more paid admissions than the Red Sox, the Patriots, the Bruins and the Celtics combined. Children, families, and adults come to science museums because they want to, not because they're required, and they indicate their level of support by their participation.

Across the United States, the science museums are expanding at an unprecedented rate. Four out of five are either expanding facilities or building new facilities. In cities including Philadelphia, Boston, St. Louis, Louisville, and Ft. Lauderdale, capital projects for new construction or renovation total over $600 million. In addition, from Pierre, South Dakota, to Ithaca, New York, to Atlanta, new science centers are opening their doors, and 45 developing members of ASTC are planning to open new science centers, and another 20 to 25 communities have asked for our support.

There is a desperate need to support and sustain this phenomenal growth in science museums and to develop the innovative and interactive exhibits in educational programs. Section 4 of the Science and Technology Education Act of 1990 provides $10 million in support and dissemination of innovative, high quality programs in science museums. This section was originally submitted as H.R. 3154 by Representative George Brown, Jr.

One of the critical concerns in the science museum field is the availability of resources not only to develop innovative programs, but to disseminate the most successful of those programs to other science museums around the United States. There is also a need to assist new and developing science museums with educational programs and exhibits, a need that can be served by teaming them with an existing and successful science museum. This act provides for the resources to accomplish both programs.

Conceptualization, planning and design is often the most costly part to development of a new program or exhibit, and these developmental costs would be shared by museums often representing geographically distant communities. The five-year plan of the National Science Foundation includes a goal for newer and smaller science museums, and section 4 of this bill would assist NSF in fulfilling that goal.

Replication offers a sensible solution for assisting both large as well as small and new science museums. Within the NSF proposed budget is $19 million allocated for informal science education as a part of the Science and Engineering Education Directorate, known as SEE, currently now a new title. Only a portion of this $19 million directly benefits science museums; therefore, the requested amount of $10 million is in addition to that current budget.

As with current informal science education grants, science museums will be required to match Federal funds with substantial local support. The Informal Science Education Program is one of the most important sources of financial support for science museums. It is also one of the most successful and objective in terms of the grant process.

In 1989, I served as the chairperson for the external peer oversight committee with the purpose of reviewing the grant process for informal science education grants at NSF. The committee concluded that the grant process was effective and successful, and our report stated, and I quote, "other Government granting agencies could benefit from the procedures in the effective review process used by the informal science education staff."

At a time when our resources are limited, they must be used wisely. The additional $10 million of the Brown bill will empower more science museums in more communities to deliver quality science experiences to the American public. Thank you very much for the opportunity to speak before you.

[The prepared statement plus letter of Dr. Wint follows:]

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Orlando, FL

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Los Angeles, CA

Dr. Robert M. West
Cranbrook Institute of Science
Bloomfield Hills, MI

TESTIMONY
TO THE
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

DRAFT BILL
SCIENCE AND TECHNOLOGY EDUCATION ACT OF 1990
SECTION FOUR

June 14, 1990

Submitted by

Dennis M. Wint, Ph.D.

Vice President
Association of Science-Technology Centers
1413 K Street, NW
Washington, DC 20005

and

President
St. Louis Science Center
5050 Oakland Avenue
St. Louis, MO 63110

AN ORGANIZATION OF MUSEUMS DEDICATED TO FURTHERING PUBLIC UNDERSTANDING AND APPRECIATION OF SCIENCE AND TECHNOLOGY

Congress is well aware of the issues facing our communities and nation concerning the underachievement of our students in science and mathematics and the negative impact this will have on the future of the United States. Numerous studies have documented the performance and the problems. Now it is time for a concerted effort at the federal, state, and local levels to improve our educational programs and student performance.

Learning does not begin at 8:00 in the morning and end at 3:00 in the afternoon for the 180 days designated as the school year. Nor is science literacy achieved in the 18-20 minutes per day given to science instruction in our elementary school classrooms. Learning opportunities are pervasive throughout society. Science museums and educational television reach millions of people annually with programs related to science, mathematics, engineering, computers, the environment, and technology.

As Vice President of the Association of Science-Technology Centers,* I can assure you that science museums are some of the most popular institutions in society. Over 75 million visitors annually attend science museums programs.

At the St. Louis Science Center, the number of visitors has increased from 275,000 in 1985 to 886,000 in 1989 as a result of new programs and hands-on exhibits and we expect almost 2 million by 1992. The Museum of Science in Boston, in 1998, had more paid admissions than the Red Sox, the Patriots, the Bruins, and the Celtics combined. Children, families, and adults come to science museums because they want to, not because they are required. They indicate support for our programs by their attendance.

The growth of science museums is further evidence of their popularity and value to the community. Across the entire United States, established science museums are expanding at an unprecedented rate.

Four out of five science museums are either expanding or building new facilities. In 40 cities, including Philadelphia, Boston, St. Louis, Louisville, and Fort Lauderdale, capital projects for new construction or renovation total over $600 million. The support for this expansion is driven by parents, formal educational institutions, businesses, local and state government and other nonfederal sources.

*The Association of Science-Technology Centers (ASTC) has 195 science centers and museums in the United States and 58 in other countries.

In addition, from Pierre, South Dakota, to Ithaca, New York, to Atlanta, new science museums are opening their doors to audiences searching for quality science educational experiences. Forty-five developing members of ASTC are planning to open new science museums, and another 20-25 communities have asked for assistance.

There is a desperate need to support and sustain the phenomenal growth of science museums and to accelerate the development of innovative, interactive exhibits and education programs thereby increasing the scientific and technological literacy of families, students, teachers, adults, and underrepresented audiences.

Section 4 of the Science and Technology Education Act of 1990 provides $10 million to support the development and dissemination of innovative, high quality programs in science museums. This section was originally submitted as H.R. 3154 by Representative George Brown, Jr.

One of the critical concerns in the science museum field is the availability of resources to develop not only innovative programs, but to disseminate the most successful programs to other science museums throughout the United States. There is also a need to assist new and developing science museums with educational programs and exhibits, a need which can be served by teaming them with existing and successful science museums.

This Act would provide the resources to accomplish both purposes. Conceptualization, planning, and design is often the most costly part of a new program or exhibit. The developmental costs of new programs would be shared by museums from geographically distant communities. And the experience and expertise of established museums would directly benefit new and developing museums.

The five-year plan of the National Science Foundation (NSF) includes a goal to support "newer and smaller" science museums. Section 4 of the bill would assist NSF in fulfilling that goal. Replication offers a sensible solution for assisting both large as well as small and new science museums. This concept needs to be included in the Kennedy version (S. 2114) as well.

Within the NFS proposed budget, $19 million is allocated for Informal Science Education as part of the Science and Engineering Education Directorate (SEE). Only a portion of the $19 million directly benefits science museums. Therefore, the requested amount of $10 million is in addition to the current budget. As with current Informal Science Education grants, science museums would be required to match the federal funds with substantial local support.

In 1989, I served as the chairperson of the External Peer Oversight Committee with the purpose of reviewing the grant process for Informal Science Education grants at NSF. The committee concluded the grant process was effective and successful. Our report stated "Other governmental granting agencies could benefit from the procedures and effective review process used by the Informal Science Education staff."

At a time when our resources are limited and must be used wisely, the additional $10 million of the Brown plan will empower more science museums, in more communities to deliver quality science experiences to the American public. It is a modest investment in our future.

I also serve as vice chairperson of the SEE Advisory Committee. Earlier this week, the Committee discussed at length the reorganization of SEE into the directorate for Education and Human Resources (EHR). I have been authorized to provide the attached comments and recommendations for your review.

I would also appreciate the opportunity to personally comment on this reorganization. I commend Bassam Shakhashiri for his leadership and dedication in bringing science education to the attention of the Nation and for advocating increased funding for precollege science education programs.

Within the new organizational structure, education and research will work closely together. I applaud this approach for a united effort. However, precollege science education must continue to receive appropriate funding to provide the innovative and creative programs science museums desperately need to address the fundamental problems of science literacy in this Nation.

Funding for science education has dramatically increased during the past several years. I urge Congress to continue to increase support for science education at the precollege level, and that this support is in addition to--but separate and distinct from--distributed and cross-funded educational programs in the research directorates.

Comments and Recommendations to Congress by the Advisory Committee to the Directorate for Education and Human Resources National Science Foundation

June 12, 1990

The Education and Human Resources Advisory Committee (previously the Science and Engineering Education Advisory Committee) discussed at length the reorganization culminating in the establishment of the Directorate for Education and Human Resources. The Committee approved the following comments and recommendations:

The Committee expresses appreciation to the Congress for its role in supporting and improving the funding for science and engineering education over the past seven years.

The Committee commends Dr. Bassam Shakhashiri for serving as a spokesperson and catalyst for action, for his extraordinary success in increasing the importance of science education at the precollege and undergraduate level, and for dramatically increasing NSF funding for science and engineering education from the budget level low points of 1982 and 1983.

The Committee recommends that future Directors of NSF have a strong commitment to education and human resource development. The Committee is eager to present and discuss its views on the future of science and engineering education with the Director, the National Science Board, and with the scientific, engineering, and education communities.

This Committee must have an advisory role to assist in the establishment of policy and program not only with respect to the activities of the Directcrate for Education and Human Resources but in relation to all educational and human resources programs wherever sited within NSF.

The Committee calls for the National Science Board to strengthen the role played by NSF in leading the national efforts to achieve the mathematics and science student achievement goals for the year 2000 set by President Bush and the Governcrs of the states.

The Committee is supportive of proposals to increase the interaction between education and research and to enhance the collaboration between those communities. It recommends that NSF's programming exemplify the equal importance of education and disciplinary research.

The Committee recommends increased emphasis and support for both action and research in program assessment and for research on teaching and learning.

The Committee recommends that the NSF appropriation for science and engineering education activities be increased to a minimum of $600 million by FY 1993, including expanded funding for pre-college and undergraduate programs. It is recommended that similarly expanded appropriations be provided for the NSF's human resources activities. The authority and responsibility for both these budget elements should lie clearly with the Assistant Director for Education and Human Resources.

The Committee is encouraged by the preliminary comments of the Assistant Director of the Education and Human Resources about his continuing commitment to science education at the pre-college and undergraduate level.

The Committee recommends that the Assistant Director for Education and Human Resources serve as the spokesperson for science education both for NSF and other Federal agencies.

St. Louis Science Center

5050 Oakland Avenue
St. Louis, Missouri 63110
(314) 289-4400

JUL 23 1990

July 16, 1990

The Honorable Timothy Valentine
U.S. House of Representatives
1510 Longworth, HOB
Washington, D.C. 20515

Dear Congressman Valentine:

I very much appreciated the opportunity to testify before the House Subcommittee on Science, Research, and Technology in support of the Science and Technology Act of 1990, particularly, Section 4 on the Science Museum Assistance Act.

Congress has been the leader in restoring the science education program in the National Science Foundation (NSF). I applaud the support of Congress and your efforts in restoring and increasing the funding, particularly at the pre-college and undergraduate levels.

Section 4 of the Bill is important to the science museums community. As I mentioned during my testimony, additional resources are needed to continue the development of innovative, successful education and exhibition programs, and to replicate these programs to other museums throughout the country. The teaming of an established and successful science museum with a developing museum will further extend the effectiveness of the investment.

I wish to clarify one issue in my testimony. In my oral comments, I mentioned that the qualifications for the future director of NSF must include a strong commitment to science education at the precollege and undergraduate level. I sensed the committee interpreted my comment as referring to the Assistant Director for Education and Human Resources, and I trust this misunderstanding will not cause an undue problem.

On another matter is the reorganization of the Science and Engineering Education (SEE) directorate into the Education and Human Resources directorate. I hope that your committee will remain vigilant and monitor the science education programs. I am particularly concerned the pre-college education programs may be reduced or greatly eliminated.

Thank you again for the your support and the opportunity to express my comments on this important bill. If I can be of further assistance, please do not hesitate to contact me.

Sincerely,

Dennis M Wint

Dennis M. Wint
President

DMW/gah

Mr. **Valentine**. Thank you, sir.

Mr. Shafer?

STATEMENT OF ROY L. SHAFER, PRESIDENT, OHIO'S CENTER OF SCIENCE AND INDUSTRY, COLUMBUS, OH

Mr. **Shafer**. Thank you, Mr. Chairman, members of the committee. After Dennis' remarks, I have an opportunity to offer a few more focused ones, and one particular place, at Ohio's Center of Science and Industry, which we call COSI, in Columbus, called KIDSPACE. It's an area that has literally changed millions of lives by putting unique opportunities for self-discovery in the hands of some of our youngest explorers.

They discover what sinks and floats in Waterworks, learn how to safely interact with other living things in AnimaLab—safety both for themselves and the other living things, by the way—and how to make their own music in the Sound Studio, conduct a high tech Kids Quartet, ride the high seas in a rubber raft on a waterbed, and take today's technology in their own hands through Computers Galore.

KIDSPACE is motivating parents and grandparents alike to bring their youngest children to COSI earlier, not after they're old enough to appreciate it, but now, when they're natural curiosities about the world can be stimulated and observation and self-discovery skills strengthened.

Our Science of Sports exhibition is in its 21st city since opening at COSI in June of 1984 and has been experienced by over 10 million visitors to science centers across America. Visitors discover that friction management is key in many sports, a baseball bat and hockey stick are really just levers, and why an ice skater spins faster with their arms close to their sides by doing all of those things themselves.

The supporting curriculum materials for the Science of Sports—encouraging visitors to participate in a science decathlon, test their reaction times, and discover the center of mass of a gymnast—were sponsored by the National Science Foundation, and I believe you have a sample of those materials before you.

Even weekend nights are alive at COSI, with kids exploring, experimenting and experiencing science. Since COSI invented Camp-Ins in 1972, over half a miilion girls have discovered that science is intriguing and fun when it's hands-on and understandable. This extremely popular program has been replicated by over 50 other science centers who are now wall-to-wall campers, too.

Our science is motivating and captivating, as well as open-ended. It frequently results in more questions than answers, empowers self-initiated discovery, and, most of all, it's fun. One young student perhaps summarized it best when she said, "I had so much fun at COSI, almost before I knew it, I learned something."

Section 4 of the committee's bill provides a plan to build on these success stories and literally hundreds of others at science centers across the country. In essence, it offers emerging science centers a franchise package, if you will: not just plans or even exhibits with no assembly instructions let alone maintenance plans, but a network for staff development and training, program design and implementation, and an already successful sounding board on which to test new ideas.

Just as we have developed programs across the country to hasten technology transfer, section 4 creates a transfer scenario for emerging science centers to ensure that not only will already successful exhibitions and programs find their way into the hands of millions of kids from two to 102 across the country, they'll be successful and effective as well.

We very much need to reduce the extraordinarily steep learning curve facing an emerging science center, which was faced by today's highly successful ones in their early days, too. The franchising concept offers an extraordinary return of investment as well, dramatically spreading research and development costs, as well as scarce human design talent, while maximizing our success ratio.

In some ways, COSI has already tested the section 4 plan with other science centers. We were instrumental in the start-up of Science Spectrum in Lubbock, Texas, building and installing basic science exhibits there and helping to structure and train their staff. We continue to support them, although in a very limited way, as a sounding board for new ideas and plans.

We have fully replicated KIDSPACE and installed it in a new science center, Sci-Trek, in Atlanta, as well as portions of it in Dallas, Jacksonville, Amarillo, Seattle, and, as of this week, Formosa.

We know it works; we know how it works; we simply need support to carry it out effectively in light of the challenges we all face in the growth of our own institutions. We can deliver the best far sooner than the first Camp-In spinoff, which occurred 10 full years after it was already a proven success at COSI. Thank you.

[The prepared statement of Mr. Shafer follows:]

COSI
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Columbus, Ohio 43215-3773
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(614) 228-COSI
OHIO'S CENTER OF SCIENCE & INDUSTRY

Statement Of

Roy L. Shafer

President & CEO

COSI, Ohio's Center Of Science & Industry

Before The

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

United States House of Representatives

June 14, 1990

A private not-for-profit organization, 97% privately funded, and sponsored by The Franklin County Historical Society

27th year

At COSI, Ohio's Center of Science & Industry, in Columbus, there is an extraordinary place for young children and their favorite grown-ups---KIDSPACE! KIDSPACE has changed literally millions of lives by putting unique opportunities for self-discovery in the hands of our youngest explorers. They discover what sinks and floats in Waterworks; learn how to safely interact with other living things in AnimaLab, make their own kind of music in the Sound Studio, conduct the high-tech Kids Quartet, ride the high seas in a rubber raft on a waterbed and take today's technology into their own hands through Computers galore.

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Section 4 of the Committee's bill provides a plan to build on these success stories and hundreds of others at science centers across the country. In essence, it offers emerging science centers a "franchise package;" not just plans or even exhibits (with no assembly instructions let alone maintenance plans) but a network for staff development and training, program design and implementation and an already successful sounding board on which to test new ideas.

Just as we've developed programs across the country to hasten technology transfer, Section 4 creates a transfer scenario for emerging science centers; to ensure that not only will already successful exhibitions and programs find their way into the hands of millions of kids from 2 to 102, they'll be successful and effective as well. (We need to reduce the extraordinarily steep learning curve facing an emerging science center; which was faced by today's highly successful ones in their early days too.

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In some ways, COSI has already tested the Section 4 plan with other science centers. We were instrumental in the start-up of Science Spectrum in Lubbock, Texas (building and installing basic science exhibits and helping to structure and train their staff) and continue to support them, in a very limited way, as a sounding board for new ideas and plans. We've also fully replicated KIDSPACE and installed it in a new science center, Sci-Trek, in Atlanta as well as portions of it in Dallas, Jacksonville, Amarillo, Seattle and as of this week, Formosa.

We know it works; we simply need support to carry it out effectively in the light of the challenges we all face in our own institutions' growth. We can deliver the best far sooner than the first Camp-In spin-off which occurred 10 years after it was already a proven success at COSI.

Mr. VALENTINE. Thank you, sir.
Mr. Krakauer?

STATEMENT OF DR. THOMAS H. KRAKAUER, DIRECTOR, NORTH CAROLINA MUSEUM OF LIFE AND SCIENCE, DURHAM, NC

Dr. KRAKAUER. Mr. Valentine, I think I am a case study for what this bill is attempting to achieve. A new exhibit, called "BodyTech: the Science Behind Medicine," has just opened at the North Carolina Museum of Life and Science. The 2,000 square foot exhibit is a significant new initiative that links physics and biology to teach people how the human body works. It's a hands-on exhibit that successfully gets students and adults to explore and raise questions about the marvelous machinery of their body.

You can imagine their reaction to pumping blood through an artificial heart valve or coming up face-to-face with a skeleton that is surgically implanted with replacement parts or a grandparent being able to talk to one of their grandchildren about the surgery that they have just had and demonstrating how an artificial hip joint works.

BodyTech was developed over a three-year period with $288,000 in National Science Foundation funds through the Informal Science Education Program. It provides an outstanding example how National Science Foundation Federal funds leverage the private sector support, including funds from IBM, Burroughs Wellcome Fund, Duke University, and the Kate B. Reynolds Health Care Trust.

Private sector funders are eager and more than willing to support projects that have received National Science Foundation funding and have undergone the rigorous peer review that an NSF grant requires. Private, corporate and Foundation dollars created an exhibit that doubled the Federal investment in the $600,000 BodyTech exhibit.

The exhibit is open and has received national attention, including coverage on Cable News Network. It's being used by children, by families, by allied health professionals, and by disabled visitors. Educational programs ensure the fullest integration of the exhibit into school curricula.

But now what? The exhibit exists in Durham, North Carolina, and I am certain that Representative Valentine is pleased about its location. But there is significant interest throughout the United States to obtain copies of BodyTech, to obtain plans, to purchase components, or to exhibit a traveling version.

These requests have come from developing institutions, as well as some of the largest museums in the country, including the Buhl Science Center in Pittsburgh, Pennsylvania, the International Museum of Surgical Science in Chicago, Illinois, the Liberty Science Center in Jersey City, New Jersey, and the Imaginarium in Anchorage, Alaska. International requests have come from as far away as Auckland, New Zealand.

The investment of intellectual capital represents a very significant portion of the cost of developing any exhibit or program. Shouldn't other communities in the United States be able to benefit from this major investment in capital? Why should each museum redo the research, redesign the exhibit, reengineer the hands-on devices, retest and evaluate? That's way too many "re's." The concept of reinventing the wheel comes quickly to mind.

No other component of our national educational enterprise is structured in such a way that this investment in intellectual capital is not replicated and disseminated as widely as possible. In formal education, a curriculum is developed and then disseminated. Shouldn't the same process be followed in informal education?

Section 4 of the Science and Technology Education Act is specifically targeted to address these issues. The bill will benefit all categories of science-technology museums. Emerging museums will benefit directly from the new science center initiative. Small- to midsize museums, such as the one in Durham, will be strengthened by being both providers of services and recipients of model programs. Larger institutions, by being providers of service, can much better justify their significant investment of intellectual and real capital in innovative educational programs and exhibits.

The Congressional findings that are the motivation for the Science and Technology Education Act are directly addressed in a very cost effective way by the informal science education provisions in this proposed legislation. As the Executive Director of a science-technology museum in a high technology area whose economic viability depends upon developing a scientifically motivated work force, I urge the creation and the passage of this bill.

I further applaud the goal of encouraging funding for programs serving disadvantaged populations. Durham, even though it has one of the highest percentages of both M.D.s and Ph.D.s in the Nation, also has a city school system which is 90 percent minority and overwhelmingly disadvantaged. This bill will provide the sort of high interest, high energy programs and exhibits that are offered at science centers. These are what opens students' eyes and minds in a way that public education appears to be unable to do. Thank you.

[The prepared statement of Dr. Krakauer follows:]

North Carolina Museum of Life and Science
433 Murray Avenue • P.O. Box 15190 • Durham, NC 27704 • (919) 477-0431 • Fax (919) 477-7112

Statement by
Thomas H. Krakauer, Ph.D., Executive Director
North Carolina Museum of Life and Science
Durham, North Carolina

Before the
Subcommittee on Science, Research and Technology
U.S. House of Representatives
Tim Valentine, Chairman

On the
Science and Technology Act of 1990
Section 4

June 14, 1990

A new exhibit called *BodyTech - the Science Behind Medicine* has just opened at the **North Carolina Museum of Life and Science**. This $600,000 exhibit is a significant new initiative, linking physics and biology to teach people how the human body works. The hands-on exhibit successfully gets students and adults to explore, and to raise questions about the marvelous machinery of the body. You can imagine the reaction to pumping blood through an artificial heart valve, or coming face to face with a skeleton surgically implanted with replacement parts.

BodyTech was in development over a three year period with $288,000 in federal National Science Foundation funds through the Informal Science Education Program. It provides an outstanding example of how NSF federal funds leveraged private sector support including IBM, Burroughs Wellcome Fund, Duke University, and the Kate B. Reynolds Health Care Trust.

Private sector funders support projects that have received NSF funding and have undergone rigorous peer review at the national level. Private, corporate, and foundation dollars created an exhibit that doubled the federal investment in the $600,000 *BodyTech* exhibit.

The exhibit is open and has received national attention on CNN. It is being used by children and families, by allied health professionals, teachers, and by disabled visitors. Educational programs ensure the fullest integration of the exhibit into school curricula.

Now what? The exhibit exists in Durham, North Carolina. There is significant interest from throughout the United States to obtain a copy of *BodyTech*, to obtain plans, to obtain components, and to exhibit a traveling version. These requests have come from developing museums, as well as some of the largest museums in the country, including:

- Buhl Science Center, Pittsburgh, Pennsylvania
- Catawba Science Center, Hickory, North Carolina
- Children's Museum of Bettendorf, Bettendorf, Iowa
- Cumberland Science Center, Nashville, Tennessee
- Discovery Place of Birmingham, Birmingham, Alabama
- Evansville Museum of Art and Science, Evansville, Indiana
- Heritage-Hjemkomst Interpretive Center, Moorhead, Minnesota
- International Museum of Surgical Science, Chicago, Illinois
- Kansas Learning Center for Health, Halstead, Kansas
- Lawrence Hall of Science, Berkeley, California
- Liberty Science Center, Jersey City, New Jersey
- Maryland Science Center, Baltimore, Maryland
- Museum of Science, Boston, Massachusetts
- Museum of Science and Industry, Chicago, Illinois
- Museum of Science and Industry, Tampa, Florida
- Northwest Museum of Health and Science, Spokane, Washington
- Oregon Museum of Science and Industry, Portland, Oregon
- Science Museum of Virginia, Richmond, Virginia

South Carolina State Museum, Columbia, South Carolina
St. Louis Science Center, St. Louis, Missouri
The Imaginarium, Anchorage, Alaska

International requests have come from:
Alberta Science Center, Calgary, Alberta, Canada
Edmonton Space Sciences Foundation, Edmonton, Alberta, Canada
Industrial Heritage Museum, Leichester, England
Satrosphere, Aberdeen, Scotland
The Museum of Transport and Technology of New Zealand Trust, Auckland, NZ
The Wellcome Trust, London, England

This response is a fantastic endorsement of the exhibit, but is an even stronger indication of the crying need for exemplary quality hands-on science exhibits.

What makes a good exhibit? A good exhibit translates complex scientific principles into tangible demonstrations comprehensible by a wide and diverse audience. The best exhibits are tools of discovery; allowing visitors to test, experiment, explore and understand. Open-ended exploration is key - you can't flunk an exhibit!

Developing quality exhibits is a complex process. In many ways, it combines the most difficult portions of architecture, and developing a new product for the marketplace. Each exhibit requires investment in research, planning and evaluation. Academic and corporate scientists, consultants and museum staff spend months identifying exhibit concepts and approaches.

Exhibits require one-of-a-kind engineering with careful attention to durability, accessibility and aesthetics. Exhibits must endure the active exploration of excited school groups on a spring field trip and still be in working order for the studious future scientist.

The investment of intellectual capital represents a very significant portion of th costs of developing an exhibit or a program. Shouldn't other communities in the U.S. be able to benefit from this major investment of intellectual capital? Why should each museum redo the research? Re-design the exhibit? Re-engineer the hands-on devices? Re-test and evaluate? That is too many "re's"!! The concept of re-inventing the wheel comes quickly to mind.

No other component of our national education enterprise is structured in such a way that the investment in intellectual capital is not replicated and disseminated as widely as possible. In formal education, a curriculum is developed and then disseminated. Shouldn't the same process be followed in informal education?

Section 4 of the Science and Technology Education Act is specifically targeted to address these issues. The bill will benefit all categories of science-technology museums. Emerging museums will benefit directly from the new science museum initiative. Small to mid-sized museums will be strengthened by being both providers of services and recipients of model programs. Larger institutions, by being providers of service, can better justify their investment of intellectual and real capital in innovative educational programs and exhibits.

The congressional findings that are motivation for the Science and Technology Education Act are directly addressed in a cost effective way by the new Informal Science Education provisions of this proposed legislation. As the executive director of a science-technology museum in a high technology area whose economic viability depends upon developing a scientifically motivated workforce, I urge the passage of the bill.

I further applaud the goal of encouraging funding for programs serving disadvantaged populations. Durham, North Carolina, with one of the highest percentage of both MD's and Ph.D's in the nation, also has a city school system which is 90% minority and overwhelmingly disadvantaged. This bill will provide the sorts of high interest, high energy programs and exhibits that are offered at science centers. They are what can open students' eyes and minds in a way that public education appears to be unable to do.

Thank you.

Thomas H. Krakauer

Born in Buffalo, New York

EDUCATION:

Ph.D. - University of Florida, 1970: Major - Zoology;
Minor - Physiology

A.B. - University of Rochester, Rochester, New York, 1964: Major Biology

PROFESSIONAL EXPERIENCE:

1985-Present	Executive Director North Carolina Museum of Life and Science, Durham, North Carolina
1974-1985	Founding Executive Director Science Museum Association of Roanoke Valley, Roanoke, Virginia
1970-1974	Assistant Professor of Biology Hollins, Roanoke, Virginia

PROFESSIONAL RECOGNITION:

- Association of Science Technology Centers: Vice-President, 1985-1986. Current Board Member. Chairman of Audit Committee, Co-Chair of Long-Range Planning Committee.

- Virginia History & Museums Federation: President, Vice-President, Secretary; re-elected to Board, 1984.

- Conservation Educator of the Year, 1978. Named by the Virginia Wildlife Federation.

North Carolina Museum of Life and Science
433 Murray Avenue • P.O. Box 15190 • Durham, NC 27704 • (919) 477-0431 • Fax (919) 477-7112

Museum Service Indicators At A Glance (1989)

Population, Durham County: 179,065

Enrollment, Durham Public Schools: 26,032

Total Museum services: 150,380

Museum services provided as a percentage of multi-county population: 24.3%

Total Museum attendance: 134,947

Group attendance: 55,952

Museum group visits by Durham students: 11,461

Students served in school programs at the Museum: 10,032

Students served in outreach programs: 15,433

Individuals served in other Museum programs: 24,610

Teachers trained in teacher workshops: 545

Science kits in circulation: 300

Source: Public Relations Office, North Carolina Museum of Life and Science, Durham, North Carolina.

North Carolina Museum of Life and Science
433 Murray Avenue • P.O. Box 15190 • Durham, NC 27704 • (919) 477-0431 • Fax (919) 477-7112

The North Carolina Museum of Life and Science had its beginnings in 1946, in a cottage where children learned about the wonders of the world around them by touching small animals and objects of nature. That early foundation of providing hands-on experiences has continued over the years and helped develop the Museum into a 78-acre regional science-technology center offering learning opportunities for people of all ages from all walks of life.

Programs and exhibits combine science and fun, while at the same time providing meaningful experiences which stimulate a sense of discovery and develop creativity. Through informal means, participants engage in the same processes scientists use as they collect data, form hypotheses, and draw conclusions. The agonizing tests and failure often associated with science are replaced with experimenting by stretching, pressing, pounding, pouring, stirring, and engaging in other interactions.

The crisis in science education is being addressed on many levels. Teacher workshops, school programs at the Museum, outreach programs, teacher workshops, and science kits are among resources provided to schools, specifically to teachers, to help them meet and exceed their science curriculum requirements.

Working toward achieving scientific literacy among all socioeconomic groups within the Triangle is a priority. Minorities, women, and disadvantaged populations — all groups with high interest but traditionally low participation in the sciences — are sought out through Community Partners programs, Black Church projects, Family Science workshops, Girl Scout Camp-Ins, After-School programs in inner city schools, and outreach programs in senior centers.

Mr. VALENTINE. Thank you, sir.

Ms. Levine?

STATEMENT OF ILMA S. LEVINE, DIRECTOR, SCIENCENTER, ITHACA, NY

Ms. LEVINE. I appreciate the opportunity to testify before you today, and I am here to represent small science centers and to tell you how much section 4 of the proposed legislation could mean to us.

I'm from the Sciencenter, a small science museum in Ithaca, New York. We opened in 1984 in donated space, and we have moved three times since then, each time housing ourselves in donated space in prime business locations donated by the business community. Almost all of our work is done by volunteers.

Ithaca is located in Tompkins County. It's a diverse area. Its business is education. It's home to Cornell University, Ithaca College, and several other small colleges. Its citizens have among the highest average education levels in the State, but the area also includes a sizable economically disadvantaged population. Most of the people in the county work for the educational institutions, but they're not all college professors.

The Sciencenter has become a really well-established part of the community, even though we are small and in donated space. In 1989, we had 10,000 visitors. Now, when you compare that to the two million I heard from one of the other individuals, that doesn't sound like a lot of people, but our total county population is 80,000. So when you look at it in that light, this level of activity means that we are popular and valued.

As we expand our outreach programs, and we have a number of them, we find that we cannot meet the demand. As an all volunteer organization, we have come to the point where we realize we have to either fold up our tents and go away or grow.

We have strong ties with local schools and teachers. We've just recently completed a project to provide curricular materials and kits to our Ithaca City School District for elementary classroom use, and in that way we have benefitted directly—the Sciencenter has benefitted directly—well over 2,000 school children and will continue to do so every year through the kits and materials.

Our Board of Directors has decided that we can no longer function as a small volunteer organization in temporary, inadequate space. We've assigned top priority to the establishment of a new Sciencenter in a permanent facility, and Congressman Boehlert can testify to the fact that we are in a very small space.

The entire community will be involved in this building of the new Sciencenter. We are going to do it through a community process where we have already started to solicit contributions of donations of labor and materials from local business people, from individuals, from corporations. We will soon be entering on a capital campaign and asking them for money also. But individuals in the community—children, adults, professional people, lay people—are all contributing with respect to ideas, work, expertise. Whatever they can contribute is going into the new Sciencenter. We are currently searching for our first paid executive director, and we plan to start interviewing. We have a number of candidates who look very promising.

Section 4 of the Science and Technology Education Act brings with it the promise of needed assistance. We have the volunteers who are experienced in the design and fabrication of exhibits, but we need the ability to obtain selected exhibits from other museums. We have some capacity to produce innovative, high quality exhibits in a number of areas, but we lack capacity in others. We need to be able to draw on the strengths of other museums so that we can concentrate our own efforts most effectively.

Small museums cannot accomplish all of the things that are done in large museums, but we really do some things better. At our Sciencenter, we have large numbers of repeat visits, youngsters who come alone or with their parents every week. We know many of them by name. We advise them; we sometimes help them with their homework. More often we suggest science fair projects; we tell them where to buy the parts; sometimes we order them specially for these projects. We advise parents; we tell them what books their children may benefit from; and we have the same kind of relationship with teachers who come in to look at our resource materials.

We have a very nice library of resource materials. We don't have a formal resource center, but we have a copying machine, and teachers come all the time to make use of what we have. We feel we have the ability to really make a difference in our community.

The pending legislation offers the potential for doing more than simply helping small developing science centers like ourselves. It recognizes the unique strengths of small museums. We need funding to develop programs that will meet the needs of our community, especially the disadvantaged children who are difficult to reach and too often overlooked.

We support section 4, and we believe it will be effective in providing assistance where it is needed. We're prepared to take full advantage of it. We know also that our local donors will be even more generous in helping to support projects that have the National Science Foundation stamp of approval.

What can we use now? Well, we can use some of the things that were talked about here. We'd love to have your BodyTech, your replaceable hip part. We might be able to use part of KIDSPACE. We certainly want to take advantage of what has been developed by the larger institutions with more expertise.

Even before we have our new home, we can use discovery boxes to lend to classroom teachers and day care providers. We have a lot of requests from day care providers, and we are not able. We had a small grant from our State Arts Council a couple of years ago, and we went out to day care providers, and we get phone calls every week from them asking us when we can come back.

We want help in establishing a mobile science outreach program for our rural areas, and we want to benefit from the experiences of other science museums that have mobile units and have developed them successfully.

We're currently starting a project at a local Girl Scout Council to try to reach young women who typically do not enter science fields, and we want to develop more programs that will introduce young women and minorities to science.

We need to develop ongoing teacher training programs with teaching materials that integrate class visits to the center with school curricula. We know that most elementary teachers in New York State do not have a good background in science. Many have not even had a single course in physics or chemistry. We can't remedy that situation, but we can try to address it by doing workshops that really provide the teachers with the information and confidence that they need in order to be able to teach science.

We believe that the Sciencenter should be involved in providing in-service teacher training. Section 4 provides a mechanism for doing this by giving us entree to programs that have been developed in other centers. We don't have to start from the beginning and develop our own.

We strongly support merit-based competitive awards, and we want to make it clear that small does not mean low quality. Nor do we want any consideration for programs that don't have high quality attached to them. The criteria set forth in section 4—suitability for replication, potential for impact, overall excellence—seem appropriate. We hope that the interpretation of the capability to broadly disseminate programs is not based on the size of the museum.

We believe that the emphasis on strong community involvement of diverse groups in the development of programs is an outstanding feature of this legislation, and I thank you for the opportunity to testify.

[The prepared statement of Ms. Levine follows:]

Sciencenter

STATEMENT OF

ILMA S. LEVINE

CO-FOUNDER OF SCIENCENTER
ITHACA, N.Y.

BEFORE THE SUBCOMMITTEE
ON SCIENCE, RESEARCH, AND TECHNOLOGY

JUNE 14, 1990

The Sciencenter, a small science museum in Ithaca, N.Y., opened in 1984 in donated space in a downtown storefront. We are currently in our third home, with each one in donated, prime business space. We are a non-profit educational organization with an active, working Board of Directors that establishes policy and an Advisory Board that provides additional expertise. Almost all of the work is done by dedicated volunteers.

The Sciencenter was founded on the belief that improving literacy in the sciences is vital in this technological age. A prime objective is to motivate and encourage young people to continue their studies in science and engineering. The Sciencenter is in a unique position in our community to provide outstanding interactive exhibits and public education programs in the sciences, drawing upon the resources of the area's many leading educational institutions and high technology businesses. Tompkins County, with Ithaca as its population center, is a diverse area, including urban, suburban and rural communities. It is home to Cornell University, Ithaca College, and several smaller colleges. It's citizens have among the highest average education levels in the state, yet the area includes a sizable economically disadvantaged population.

Even before we opened an exhibit space, we were involved in outreach activities and community events. The Sciencenter has, in just a few years, become an established part of the community. In 1989 we had 10,000 visitors. From a countywide population of 80,000, this level of activity means that we are a popular and valued resource. As we expand our outreach and other services, we are experiencing increasing demand. We have waiting lists for parent/child workshops and summer camp weeks, and can not satisfy the demand for after-school programs. We are experiencing increasing numbers of requests to borrow portable exhibits for local festivals and school science fairs. We loan equipment to groups and organizations in a geographical area that extends far beyond our county, and we cannot meet the demand for this service.

Our activities are not limited to informal science education. From its beginning, the Sciencenter has had strong ties with local schools and teachers. Two members of our Board are members of the Elementary Science Curriculum Committee of the Ithaca City School District. In addition to direct services to teachers, the Sciencenter has participated in school science fairs throughout the county, and has displayed school projects at the Center. Our library of science resource materials is used by a large number of teachers, as well as by youth group leaders and parents.

In 1988, the Sciencenter was awarded a $10,000 Science Teacher Education At Museums (STEAM) grant through the Association of Science-Technology Centers (ASTC). We are the smallest and newest museum to be awarded this grant. With matching funds from the Ithaca City School District and hundreds of hours of in-kind contribution from volunteer professionals at the Sciencenter, the grant was used to develop hands-on science kits and curricular materials for classroom use. Fifteen topics were developed in the pilot program; the school district then provided an additional $10,000 to replicate the kits for use in its eight elementary schools. Workshops to familiarize district elementary school teachers with the materials were held jointly by the school district and the Sciencenter. We are pleased to have been able to use the resources of the Sciencenter to directly benefit over 2,000 school children each year. There are five other school districts in Tompkins County; we do not have the capacity to undertake collaborative projects with these districts. Interaction with these schools has been limited to science fairs and visits to the Sciencenter by school groups, but the potential exists for much more.

The Sciencenter Board has decided that we can no longer function as a small, volunteer organization in temporary, inadequate space, and has assigned top priority to the establishment of a permanent facility. We have selected a preferred site and will soon complete negotiations with the City of Ithaca for use of the site. Architect Robert Leathers, internationally known for community-built projects, is the designer. The entire community will be involved throughout the design, construction and operation of the new Sciencenter -- it will "belong" to everyone who has invested time, energy, expertise or money in its development. Design and prototyping of exhibits is under way. A major capital campaign will be launched in the near future. A search for a paid Executive Director is under way, but the Sciencenter will continue to rely heavily on volunteers.

As the Sciencenter works to become a community resource that can respond to and meet the needs of our area, it needs help. We anticipate continuing and increasing community support and have already enlisted the assistance of leading business people, educators and scientists.

To realize our full potential, we also need help from outside sources. Section 4 of the Science and Technology Education Act brings with it the promise of important and needed assistance. We need access to guidance from larger science museums with experience in developing outstanding exhibits and successful programs. We have found that other science museums are willing to share ideas with us and are supportive, but we have not been able to find funding to enable us to take real advantage of their expertise. Exhibits for the new Sciencenter are being designed and prototyped now. We have volunteers who are experienced in design and fabrication of exhibits, but we need the ability to obtain selected exhibits from other museums. While we have the capacity to produce innovative, high quality exhibits in a number of areas, we lack capacity in others. We need to be able to draw on the strengths of other museums so that we can concentrate our own efforts most effectively.

This pending legislation offers the potential for doing more than simply "helping" small, developing science centers -- it recognizes the unique strengths of small museums and offers them a chance to obtain funding for programs designed for their communities. We need funding to develop programs that will meet the needs of our community, especially the disadvantaged children who are difficult to reach and too often overlooked.

In this respect, small science centers are a critical link in science education; they have the capability to establish lasting personalized ties with their own populations and to provide uniquely effective programs. At the Sciencenter, we have large numbers of repeat visits -- youngsters who come alone or with their parents every week to tinker with a pump, build a better bridge or watch the salamanders in the terrarium eat flies. We know many of them by name. We show them how to make pictures for the zoetrope and help them choose topics for their school science projects. Parents ask us to suggest science books and borrow our science supply catalogs. Small museums cannot accomplish all of the things that are done in large museums, but we do some things better. We are able to tailor our programs to local needs and to develop individual, on-going relationships with youngsters, with their parents, and with their teachers. We have the ability to really make a difference.

The Sciencenter supports Section 4 and believes it will be effective in providing assistance where it is needed. We are prepared to take full advantage of it. We know also that our local donors will be even more generous in helping to support projects that have the National Science Foundation stamp of approval. What can we use now? Even before we have our new home, we need "discovery boxes" to lend to classroom teachers and to day-care providers and youth groups. We want help in establishing a mobile science outreach program for our rural areas and access to programs that have proven successful in other communities. Most of the larger science museums are located in urban areas and have developed programs to meet needs of urban and suburban populations. We need the opportunity to collaborate with large museums and with other small museums to develop effective programs that address the critical needs of the rural population.

A very small Community Partnership Grant from ASTC will enable the Sciencenter to establish a collaborative project with The Seven Lakes Girl Scouts Council and encourage girls' interest in science and math. We are in the process of developing this program and will carry it out during the coming year. The target group in Tompkins County consists of 25 troops (over 400 girls); the potential exists for extending the program to the twelve other counties served by the Council. We have already had requests to share this program with others (one request is from Hawaii). But we want to be able to do more. We want to develop more programs that will introduce young women and minorities -- groups traditionally underrepresented in the sciences -- to challenging and exciting science and math activities. We want to be able to work with local schools and with our colleges and universities to encourage children to think of careers in science and engineering.

A recent Sciencenter event honored selected teachers from all the districts in the county -- elementary, middle school and high school. Many of the teachers expressed interest in actively working on curricular materials to be used by school groups in conjunction with the exhibits at the new Sciencenter. The Sciencenter has used its resources to help improve the scope and quality of science teaching in schools. We need to develop ongoing teacher-training programs and teaching materials that integrate class visits to the center with school curricula. We know that most elementary teachers in New York State do not have a background in science and many have never even had a single course in physics or chemistry. We believe that the Sciencenter should be involved in providing in-service teacher training; Section 4 provides a mechanism for doing this.

The Sciencenter strongly supports merit-based, competitive awards. The criteria set forth in Section 4 -- suitability for replication, potential for impact, overall excellence -- seem appropriate. We hope that the interpretation of the capability to broadly disseminate programs is not based on the size of the museum. We believe that the emphasis on strong community involvement of diverse groups in the development of programs is an outstanding feature of this legislation.

Biographical information

Ilma S. Levine
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Ilma Levine is one of the founders of the Sciencenter and is a member of its Board of Directors. She has more than 20 years of experience in teaching science in the classroom, developing informal `hands-on' science programs in the Ithaca City School District, and in fostering the use of this approach through workshops for teachers. During 1983-86 she taught in a public school in India where she established a hands-on science program and participated in the development of science curricula and training materials. She contributed a monthly series of science activities for a children's magazine, "Target", published in New Delhi. Ms. Levine has a Master of Science Degree in Botany and Science Education from Cornell University, and holds a N.Y.S. Secondary Science Teaching Certificate. Ms. Levine received an award in 1989 from the Ithaca College chapter of Sigma Xi for her contribution to science education in the community and received a Community Service Award in 1990 from the Tompkins County Foundation.

SCIENCENTER PROGRAMS AND EVENTS:

School group visits
Group visits (day care, sheltered workshop, senior citizens)
Showtimes - Saturday afternoon demonstrations / activities
Teacher Workshops
Science / Computer Camp in cooperation with Ithaca College.
Parent/Child Workshops
Participation in science curriculum development, grades K-6,
    Ithaca Schools
Preparation of science kits for use in Ithaca Elementary Schools.
Spring vacation camp
Summer vacation camp
Day Care Activities - Outreach to 22 sites in Tompkins County.
Parent/Child Workshops
Summer science activity program at Southside Community Center
Science Club at Southside Community Center
After school pilot project
After school programs
Participation in activities / events sponsored by Pyramid Mall,
    Day Care Council, Cornell Plantations, YMCA, NYSEG, etc.
Participation in Ithaca Festival, Ellis Hollow Fair, Danby Fair,
    Fall Creek Fair, etc.
Participation in school activities (science fairs, etc.)
Participation in events sponsored by Cornell University
Sciencenter at the Tin Can - science fair
Magic Show
Excitement of Physics Show
Leonardo daVinci Exhibit - loaned by the IBM Corporation.
Inventors' Convention, in cooperation with Ithaca Schools.
Model Train Exhibit
Sciencenter Annual Egg Drop Contest
National Science and Technology Week exhibits
Cold Blooded Carnival
Building Bridges - sponsored by the Tompkins Co. Arts Council
On The Move
Participation in Natural History Network.
Exhibit Loan Program (lending exhibits to schools and
    organizations in the Finger Lakes and Southern Tier area).
Farmers' Market - weekly science activities
Youth Bureau science activities
Women in Science and Engineering - participation in workshop
    sponsored by Cornell University
Participation in 4H Natural Resources Appreciation Program
Sponsorship of 4H science clubs
Birthday parties at the Sciencenter

DONORS:

Donors for institutional development and operating expenses

Social Service League
Naro Foundation
Flerlage Foundation
Ithaco
Sigma Xi and Cornell Chapter of The American Chemical Society
Cornell Tradition, Summer Employment
California Museum Foundation
Central Elementary School students
Vector Magnetics
Ithaca College Chemistry Club
Tompkins County Foundation
Youth Bureau Summer Employment
N.Y. State Youth Employment Service
CIVITAS, work-study students and volunteers
RSVP volunteers
Donation of space
Individual volunteers

Donors for Programs

Tompkins County Foundation. To help bring school groups to the Sciencenter.

Tompkins County Arts Council. Decentralization Grant. To provide science related activities to day care children in Tompkins County.

Gannett Foundation. To develop and present workshops for preschool children and parents.

ASTC (Association for Science-Technology Centers),
STEAM Grant from General Electric Foundation.
To develop and prepare science kits for use in Ithaca Elementary Schools.

ASTC Community Partnership Grant. To develop a science badge for Girl Scouts in collaboration with the Seven Lakes Girl Scouts Council.

Tompkins County Foundation. To help fund an exhibit for the Ithaca Festival.

Tompkins County Chamber of Commerce. To help fund an exhibit for the Ithaca Festival.

SCIENCENTER BOARD OF DIRECTORS

William A. Bassett - Professor of Geological Sciences, Cornell University.

Paul Eshelman - Associate Professor, Design and Environmental Analysis, Cornell University.

Jay Hyman - Veterinarian. President, Amvet Management Corporation.

Donald Kompf, Jr. - President, The Carey McKinney Insurance Group.

Deborah Levin - Microbiologist. Science educator, The Museum of Science, Boston, and The Exploratory, Bristol, England.

Ilma S. Levine - Former science teacher, elementary and secondary.

Margaret Meno - Administrative Manager, Center for Environmental Research, Cornell University. Tax consultant, RSVP.

Leilani Peck - Research Support Specialist, Dept.of Neurobiology and Behavior, Cornell Univ. Author, nutrition textbooks. Curriculum development, nutrition.

Martha Oschrin Robertson - Exhibit designer, Cleveland Children's Museum. Early Childhood educator.

Nancy Schuler - Member, Tompkins County Board of Representatives. Former Recreational Therapist. Former member of Ithaca Common Council.

Horst J. Simon - General Manager, Engineering and Manufacturing-Ithaca, NCR Corporation.

John Schwartz - Associate Professor of Physics, Ithaca College.

Suzanne Soyring - Former elementary school teacher. Consultant, Ithaca City School District.

Bruce Thompson - Geophysicist. Vice President of Vector Magnetics, Inc., Ithaca.

SCIENCENTER ADVISORY BOARD

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Ann Druyan - Author

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Roald Hoffmann - Nobel Laureate, Chemistry. John A. Newman Professor of Physical Science, Cornell Univ.

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Mr. **Valentine**. Thank you, ma'am.

I would like to ask each one of you roughly the same type of question that I think would elicit some interesting and useful information.

Beginning with you, Ms. Levine, if you would please describe for us briefly and give us an estimate as to your budget, if you will, and how you're funded and your perception of the communications network that exists today. In other words, how would you have found out about these other things these gentlemen have described here if you hadn't come to this hearing?

Ms. **Levine**. Well, to answer your last question first, we are members of ASTC and have been from the day that we opened our doors. We've found that to be a very valuable avenue for getting information, and it has been extremely helpful to us. So that's how we would have learned of these potentially available exhibits. It would not have gotten us the money.

Mr. **Valentine**. I understand that. We're going to take care of all that stuff.

Ms. **Levine**. Okay.

Mr. **Valentine**. Well, so I can understand it a little bit better, the organization you referred to, does information come to you like in a catalog or a weekly publication?

Ms. **Levine**. No, it comes in a newsletter, and ASTC has lists of exhibits, and if they are available for loan they provide lists of those. But primarily it's through their bi-monthly newsletter.

Mr. **Valentine**. All right.

Ms. **Levine**. You asked me about our budget?

Mr. **Valentine**. Funding, yes.

Ms. **Levine**. Okay. I have to answer that in two ways. Until recently, very recently, our budget has been laughably small, under $30,000 a year. We have had no paid employees. About a year ago we did hire one person to do outreach, to go out into the schools and do after school programs, and those pretty much pay for themselves. But she also does other educational programs for us, and to keep our Sciencenter open during hours on the weekend.

So up to present, our budget has been about $30,000 a year. We get a lot of donations, copy machine donated, file cabinets, materials for doing activities, the materials for the exhibits often are donated, sometimes by the person who builds the exhibit. We do have a lot of expertise in our community, and we will continue to capitalize on that.

We have put together a proposed budget for our first year of operation in our new Sciencenter, when it is built, and that will be between $150,000 and $200,000. That gives you a feeling for the difference in scale that we hope to achieve and also the fact that we still will remain very small, because I know that in no way compares with the large museums.

Mr. **Valentine**. Thank you.

Dr. Krakauer?

Dr. **Krakauer**. The North Carolina Museum of Life and Science has an operating budget of about $1.3 million per year. Of that, we generate about 65 percent through earned income, gate receipts, classes, programs, contracts for educational services.

I think all of the colleagues up here are very much dependent on the Association of Science-Technology Centers, which is the full name of the ASTC abbreviation, for the networking, for the information about what programs and what activities are being offered and what is up for sharing.

Just to give you maybe a slightly different perspective, almost independent of a museum's size, it costs between about $3 and $8 or $9 per visitor in your operating budget. Most museums charge far less than that, so we are dependent on some Governmental support for basic operations. But $3 to $6 per visitor is what it costs us to provide the sorts of programs and activities that we're offering. I think it's almost independent of size.

Mr. VALENTINE. The funding that does not come through gate receipts and so on, does that come from the city or the county or the State?

Dr. KRAKAUER. All three, and then the Federal initiative with the Institute of Museum Services also has provided funding. My operating budget in those sources of funding do not include capital projects such as BodyTech or our expansion budget, but just the operating budget. Sixty-five percent is earned the hard way, the old-fashioned way; we earn it. And the other comes because the host community recognizes the impact that we make on science education as well as being a statement of pride in community, that when people come to Durham they see a quality institution.

Mr. VALENTINE. Thank you. You do have an admission charge?

Dr. KRAKAUER. Yes, sir, we do.

Mr. VALENTINE. What is it?

Dr. KRAKAUER. It's $3.50 for adults; it's $2.50 for senior citizens and children. School groups come at $1.75 per child on the group, and then those from Durham County, our host community, get in at no admission charge.

Mr. BOEHLERT. Mr. Chairman, if you will yield, please?

Mr. VALENTINE. Yes.

Mr. BOEHLERT. Just to pursue this, have the charges been constant? How long have you been open?

Dr. KRAKAUER. We've been open since 1946, so we may be one of the smaller but maybe one of the senior institutions.

Mr. BOEHLERT. When is the last time you had an increase in admissions?

Dr. KRAKAUER. It was in November 1989.

Mr. BOEHLERT. Did you notice a decline in attendance?

Dr. KRAKAUER. Not at all. Our attendance is about 30 percent up over what it was last year.

Mr. BOEHLERT. Okay, thank you.

Dr. KRAKAUER. That's not dollars; that's people. We opened a new facility, our new nature center. The BodyTech exhibit has had a positive impact on attendance, and then we just opened an outdoor science park. Again, the major determinant of what the attendance of a museum will be is not admissions charge or population base, but it is the size, what you have to offer, and total amount of exhibit space, the ability to be able to have high quality special exhibits, as well as the full range of educational programs.

So it's almost the field of dreams phenomenon. If you build it, they will come. If you build it bigger, more will come.

Mr. **Valentine**. And pay.

Dr. **Krakauer**. And pay. But you've got to have a host community or some other source for the difference between the 65 percent that can be self-generated and the 100 percent of what it costs, and that's the determinant.

Mr. **Valentine**. Thank you.

Mr. Shafer?

Mr. **Shafer**. Mr. Chairman, COSI, Ohio's Center of Science Industry, serves a regionally based audience of 700,000 visitors a year. Our annual operating budget is $4.2 million, 97 percent of which comes from private, non-tax sources.

Our communications network, too, is based through ASTC and our relationships with other institutions across the country. We also gain a lot of new ideas and exhibits and programs to investigate from our members and through our visitor center that operates through a computer-based network in our lobby.

Our admission charges are $5 for adults, $3 for students and children two years and older and senior citizens. We have a family rate for parents and children living in the same household of $15, and two school group rates—$2.50 on peak and $1.50 off peak. Related to Mr. Boehlert's question about admissions rate increases, we raised our admission rates in June 1988 and saw a 17 percent attendance increase in the same period.

Mr. **Boehlert**. Is the 97 percent from private sources?

Mr. **Shafer**. Yes. In the operating funds.

Mr. **Boehlert**. Foundations?

Mr. **Shafer**. We earn about 86 percent of it, and the balance of it comes through various sponsorships from foundations and memberships and so forth.

Mr. **Boehlert**. When you loan exhibits, is it loaned for profit or just for cost?

Mr. **Shafer**. It depends on how you define profit and cost. I'm not trying to be facetious.

Mr. **Boehlert**. No, I know. I'm just trying to determine if that's a source of revenue for you.

Mr. **Shafer**. Typically, the institution will always try to cover its direct costs and its indirect costs. But all of us are also in the business of returning a dividend to our shareholders, if you will, that is, of a soft nature, not a payout that you would find from a for-profit corporation.

But, obviously, as you heard in some of the testimony, the opportunity to transfer exhibitions to other institutions not only helps, I think, the recipient institution of the exhibition or program, it also helps us cost share the investment in the development, design and production of it initially as well.

Mr. **Valentine**. Dr. Wint?

Dr. **Wint**. Yes, Mr. Chairman, in response to the same question, we are also a part of the Association for Science-Technology Centers. That is one of the main sources of information for our institution. In addition to the newsletter that ASTC publishes that has been mentioned, there is also an annual meeting which this year will be in Orlando, Florida, and we will probably have near 900 museum professionals attending that program.

There are special workshops, such as the Symposium for New Science Centers, and events of that type that are really very important. I think what you'll find in the ASTC institutions is that, while we tend to have a level of entrepreneurial direction about us, we also don't have a sense of corporate competition. Whatever we can develop and share with one another only enhances the entire field. It isn't just necessary for a single institution.

The question about budget—the St. Louis Science Center serves a population of 2.4 million visitors in our Metro region. Our budget is $5 million, of which $1 million at this time is for capital projects and $4 million is for operation. This is in addition to a $34 million capital campaign that is currently underway, and we've raised just shy of $27 million.

Of the $5 million annual operating budget, 75 percent of that is from city and county tax revenues through a millage that is approved by the voters, which is assigned to their property tax. For that resource, we are a free institution and are therefore free to all people, with the exception of a few areas that we are permitted by law to charge.

In terms of our capital project, we anticipate that no more than 10 percent of the total $34 million raised will be from governmental sources, and that is from all governmental sources, not just the Federal sources.

Mr. VALENTINE. Thank you.

Mr. Boehlert?

Mr. BOEHLERT. It's a distinctly different situation that Ms. Levine finds herself in, and I'm wondering if you could submit your wish list to this committee, what would you have us do to help you and the Science Center in its plans for the future?

Ms. LEVINE. That's a very complicated question, and I don't want to pretend to answer it completely in two minutes. And I'd want to involve my colleagues at home in that wish list, but if we could depend on NSF to listen to us, to read our proposals, and to put them in perspective, because, as you're well aware, up to the present, we just haven't been able to ask for money. We don't meet the criteria, so that we're blocked from asking.

If we could submit our proposals and have them evaluated appropriately, that is, without comparing numbers with St. Louis or another large center, evaluate them on the basis of quality, on the basis of the impact they would have on the population that we serve, I think we would——

Mr. BOEHLERT. I get that expression of concern that the small, the emerging museums are finding it very difficult to get the attention of the people at NSF because the big guys have captured it?

Ms. LEVINE. It's more than difficult.

Mr. BOEHLERT. Impossible?

Ms. LEVINE. You don't answer the phone. I mean, yes, impossible.

Mr. BOEHLERT. What are the barriers that you have listed to you?

Ms. LEVINE. Well, unless my information is in error, the NSF guidelines have been that a program has to be replicable, and that in itself is not a problem. But sometimes a program that is developed for a small community may not instantly be transferable to large communities. It would be appropriate for other small communities, but that would not get the numbers of visitors or beneficiaries.

The major problem has been the numbers, that you have to show that you have hundreds of thousands, millions, of visitors, either to your institution or potentially to the programs as they are replicated.

Mr. **Boehlert**. Would you suggest that maybe we should consider directing NSF to fence off a small percentage of the total funding for the emerging institutions like yours?

Ms. **Levine**. I would think that would be an extremely helpful thing to do. I understand that administering small grants is costly, more costly in proportion to administering large grants, but I think you will also find that you get a lot for your dollar, that we can produce on a small scale good results.

Mr. **Boehlert**. Dr. Wint?

Dr. **Wint**. If I also may respond, I think another element has been that, in the past, the amount of money available for informal science education at NSF has been very small, and the position that NSF has taken is that, in order to get the best return, they have tended to fund the larger projects that had a high impact in terms of numbers of people contacted.

Until four years ago, my own institution, likewise, was not in a competitive position. The key, I think, is not so much that a small institution has not been competitive. The key is that there hasn't been enough money to serve the broader constituency, and I think that section 4 does permit us to do that by teaming a large institution with a developing institution, like in the case we've been hearing, as well as providing additional resources to really benefit everyone.

We're getting to a point now where at least we can begin to see some opportunity for resources that we've never had before.

Mr. **Boehlert**. We can thank our good colleague for his leadership, Mr. Brown.

Mr. **Valentine**. Mr. Brown?

Mr. **Brown**. I very much appreciate the testimony that all of you have provided with regard to the significance of science centers and museums and your general level of support for those provisions in the legislation before us. I wanted to explore a couple of things.

Dr. Wint, you apparently have the closest contacts with NSF, and generally you present a positive picture of their concern and efforts to support museums. Is that right?

Dr. **Wint**. Yes, very much so.

Mr. **Brown**. You indicate that the NSF's five-year plan does include the goal of supporting newer and smaller science museums, and you're particularly laudatory on their grant process for informal science education grants and consider it to be a success. How would you evaluate the level of the effort, by which we mean funding, with respect to need? I think that's the critical issue that we're trying to address in this legislation.

Dr. **Wint**. I think the issues that are before us as a Nation are critical issues that are both a combination of short term and long term. The total budget for science and engineering education, now identified as education and human resources, I believe, is $251 million, which is a small increase over the previous year's budget.

I think that NSF can and should provide that leadership role at the Federal level, because there really has not been another organization within society of any sort that has been able to really articulate that question.

It's not an issue of education or research. I believe it's an issue of education and research and that a synergistic relationship can develop, but with the understanding that the pipeline, as has been discussed many times, doesn't begin at the freshman year of college, but it really begins in the elementary school. And we have to make sure that we are establishing enough resources for those children at an early age so that they continue in the pool not only for scientists and mathematicians and engineers, but for a fundamentally literate population who can deal with the increased complexity of society today because of changes the size of technology.

I believe that NSF could well administer even substantially more money and that our goal is $600 million by fiscal year 1993 for that purpose.

Mr. **Brown**. By your goal, you're referring to the advisory committee?

Dr. **Wint**. Yes, the attachment to my statement is the result of a meeting that the advisory committee had on Monday and Tuesday of this week, and the comments and recommendations were approved at that time, which included the $600 million goal.

Mr. **Brown**. I have to remind you, and I'm sure you already know this, that historically, for the 25 years I've been on this committee, it has been a very staunch supporter of the science and engineering education program, as has been the Congress as a whole. And the problem has been to some degree that the Administration has tended to fluctuate, most drastically, of course, in the early 1980s, when it tried to eliminate the program. And it's now recovering, trying to reach the point that it was basically 10 or 12 years ago.

You'll be pleased to know that in anticipation of your recommendations, the Appropriations Committee, I think yesterday, added the amount required to provide that, if it's continued at the same rate of growth, to reach approximately that $600 million within the time frame that you're talking about. And that required increasing the Administration's budget request by another 15 percent or something like that.

Dr. **Wint**. Very good. I think we're very appreciative of that.

Mr. **Brown**. You knew they were going to do that, didn't you?

Dr. **Wint**. I had heard that that was underway. I think another important issue, then, is that with the reorganization within NSF that the new director or the future director of NSF has a strong commitment to pre-college and undergraduate education. And we would recommend that this committee make its recommendations known to the Senate so that we are in a position where we really can bring together the issue of research and education rather than having them go separate and sometimes distinct ways.

Mr. **Brown**. We appreciate your generally positive anticipation in that regard. I think that the new director will be an enthusiastic supporter of science and engineering education and perhaps be an even greater supporter of close coordination with the research directorates, and this could be a very positive development.

One question that I want to ask all of you to comment on briefly, it would be tremendously helpful to us who are supporters of science education and informal science education if we could see some indicators, some statistics, which would help us to point specifically to a correlation between the quality of the informal education in the community, such as an excellent science museum, for example, and the interest of that community reflected in its school and the performance of that community, in terms of additional students who go into science careers or something of that sort.

I know that's a very difficult thing to do, because there are many influences that work in any community. But do any of you have even anecdotal information that would suggest that a community which is rich in out-of-school informal science resources also encourages a greater interest within the schools in science and math education and a progression into science and engineering oriented careers?

Dr. **WINT**. There are a couple of studies that indicate that in terms of a nation-wide trend. In St. Louis, we see the relationship perhaps a little differently, and that is a program that is underway. It isn't going to quite respond to your statistical question, but St. Louis is working with the Board of Education of the city schools to develop a science magnet school.

I believe that, if there was not a sense that this was a creative new partnership that could be much more effective than the way that our curricula are developed today, we would not be pursuing it. To try to articulate that in statistical information, we're not able to do at this point, but very clearly, that is the next step that has to emerge.

As part of the recommendations of the committee that are on my attached comments, we see a major emphasis has to be made in the question of assessment of program success. We cannot do every program as though it was the first time we've ever done it, and it's always a pilot. We need to have some articulation and some fundamental theory which then can be replicated elsewhere. And that's the intent of the science magnet school that we are considering that would become a place to replicate not only for those students who are coming to this one school, but to the hundred elementary schools within the city of St. Louis.

Mr. **BROWN**. Do any of the others of you have any comments on that particular point?

Mr. **SHAFER**. Mr. Brown, as you are aware from your own background, it's difficult to determine causality in terms of outcome, and our research tools on the behavioral side of science are not clearly as strong as they are in the hard sciences. We have had, I think, a fair amount of experience now, having been in operation for 27 years, to see the anecdotal side. And, in fact, a new member of the staff of the National Science Foundation, Dr. Joan Leitzel, had two sons in our student volunteer program, both of them 1,000-hour gold badge student volunteers, who found a network of support among that volunteer corps for their interest in science early on and have continued to pursue it. And, in fact, one son is now entering a Ph.D. program in chemistry and credits his involvement in the science center with maintaining his interest in that program.

We are also seeing the results, particularly among young girls, of the Camp-In program experience early on in their lives and, in fact, have received letters from parents, most recently from a father whose daughter is now a chemistry major at Denison University. He is absolutely convinced that she pursued courses in science and math and chose to major in chemistry because of her experience in a workshop during the Camp-In program at COSI.

So we can see it. It tends to be longitudinal, which means it's difficult to track without a long time period to span. It's one of the reasons we're so committed to KIDSPACE, which actually picks up kids, pre-toddler age, and acquaints them so that we can continue to nurture and support their involvement in science over the long haul.

Mr. **Brown**. Dr. Krakauer?

Dr. **Krakauer**. I think the involvement of science centers in the more formal side of education is another way to respond to your question, and that is teacher workshops. There are clear indicators, particularly at the elementary level, that teachers feel uncomfortable in teaching science and feel unprepared.

I think everyone at this table is very intimately involved in working with elementary school teachers in providing them with the missing background, the missing confidence, and the hands-on tools to bring the science education to life in the classroom. So that's one part of the answer.

We are successful in the informal education, but we're more and more being called upon to serve formal education in terms of teacher training. Several years ago, a national study was done that resulted in a report called Museums for the 21st Century, and there was the sort of anecdotal summary that children that grow up in communities that have opportunities for informal science education such as museums, zoos, et cetera, et cetera, tend to do better in school whether they seek careers in science or not. But that also you can't put a square test on.

Mr. **Brown**. Sure. Well, as you know, one of the things that has disturbed those of us in Congress and, of course, the educational community, in general, is actual comparison of performance in math and science between a cross section of students in various ages in the United States versus Japan versus Germany versus any number of other countries. Those are very large scale efforts to make comparisons.

Now, what I would like to see—and, obviously, we're going to have to work to get that—is a comparison between the performance in math and science or the career achievements in math and science in a community which is rich in informal science resources versus a similar community which is not rich.

If we could establish that there was a difference in the level of performance in math and science in the schools or a greater number who pursue science and math careers in the schools, it would be a powerful argument for the support of the informal science education, which we accept on faith as being very important. But we need the kind of assessments here which would allow us to convince some of our more skeptical colleagues on occasion.

Thank you, Mr. Chairman.

Mr. VALENTINE. Mr. Buechner?

Mr. BUECHNER. Mr. Chairman, obviously, I'm quite proud of the work that Dr. Wint's done and the science center that we have there, and I know that he's answered a number of questions from my colleagues. I would like to ask the doctor if there are any programs that he would like to suggest to us that maybe we haven't considered that might spur either maybe new funding mechanisms or just new ways in which we can encourage it that may not be addressed currently in the bills before us.

Dr. WINT. I think that I would like to commend Congress for its role in supporting and improving science education. Very clearly, the change of funding has come about because of your action, and I think to continue that level of funding is what is fundamentally necessary for us.

I think what we've talked about is resources available so that we can be creative and innovative in attempting new programs, and second that we can replicate the best of those programs in other communities that don't have the resources and that really can't afford the learning curve that an institution like my own has had. Those are the two areas that I see that have the greatest need.

I see that we will continue to move toward—and this is a personal comment—more of a relationship with the formal educational institutions. I think that tie is one that is going to continually emerge, and I think that our institutions need to serve as rallying point perhaps for a community.

St. Louis says that it has the fourth greatest concentration of chemists in the world. Even if that's off by a factor of two, there's a tremendous resource within that community. It is not now organized. It is not yet brought together in a way that the best of those resources can really be used in the educational program.

I think some additional opportunities of that type which allow us to bring together in a synergistic way these really in a sense fragmented elements within our communities would be very beneficial. I think the issue of research, as we have discussed, is a crucial one, where we really can begin to articulate some outcomes of these kinds of programs. So that's what I would conclude, and maybe my colleagues have other comments as well.

Mr. BUECHNER. I'd solicit those comments, if anybody else has anything.

[No response.]

Mr. BUECHNER. Well, thank you very much, Doctor. If St. Louis obviously can put all those chemists together and maybe they can come up with a left-handed stopper for the bullpen, I'd appreciate that.

With that, I yield back, Mr. Chairman.

Mr. VALENTINE. I didn't realize that distilleries required so many chemists.

Congresswoman Morella?

Mrs. MORELLA. Thank you.

First of all, I agree with what Congressman Brown said in terms of if you can in some way come up with some evaluation tool, it would be exceedingly helpful in increasing the funding so that you can see a relationship, realizing that it shouldn't be done in a phony manner but that it should be as best as you can do it, realizing the difficulties.

But I also am curious about the kind of sharing that you do, whether it's teacher training programs, special exhibits, innovations that you may have. Is there any way that you share these ideas and successes and failures? This would be directed to all of you for any comment you may have, as we look at the big picture.

Dr. **Krakauer**. Both formally and informally, there's a tremendous amount of sharing. The exhibits programs that are noteworthy are promoted and discussed in the Association of Science-Technology Centers' newsletter, people call about them, ask about them, find out how to replicate them. The KIDSPACE replication, the Girl Scout Camp-Ins is a good example of that, and I think, while the museums directors are busily working on the cosmic things and the funding things, our education staff are talking and sharing and are finding out what they all have been doing that makes life working in a science center so exciting.

So whether anybody suggested that sharing was not a good idea, and that certainly is not what's happening. Sharing is taking place just because of the people networking and the informal networking, the workshops, the annual conferences, the reports.

Mrs. **Morella**. Can you give me an example besides what you said?

Dr. **Krakauer**. Okay, the BodyTech exhibit. We've had numerous people from institutions from the West Coast, from Houston, Texas, from throughout the East Coast, coming to the museum to examine the exhibit. Since it was funded with NSF money, we make the concept documents available; we make the plans available. So, you know, at the very concrete level, we share things of that sort.

There was recently an international conference on science parks that was hosted in St. Louis, and representatives from throughout the United States and from around the world came together to talk about specific ideas as to how to take the science exhibits outdoors and disseminate them away from the building.

Mrs. **Morella**. I'd like to direct it to the other panelists and ask you if you could just add also if there is something that should be done to enhance communication or if you're satisfied with the way it's going now.

Mr. **Shafer**. Congresswoman, I think you've hit the pivotal issue. We have seen an extraordinary exchange, I think. If you look at any industry, whether it be Monsanto or the breweries, if we take St. Louis as the example, there's not a lot of exchange within the industry of proprietary information. And between the science-technology centers, there's been an extraordinary exchange of exhibition concepts and programs.

Our own Camp-In program, which began in 1972, now has been replicated in well over 50 other museums. The key question, though, is that the first one occurred in a very small science center in Des Moines, Iowa, 10 years after it was already a proven success in Columbus, Ohio, at COSI. We have to increase the rate of technology transfer, if you will, among the program and exhibition elements between the existing and new and emerging science-technology centers, and that's why section 4 of your bill is so important.

It takes the best of the best and speeds its transfer—adaptation and adoption, not lock, stock and barrel, but adapted to meet individual audience needs—very effectively by building off of those existing programs that are successful. We've been doing it, we just need to do it faster, better, more effectively, because the gains to be realized in terms of quality, quantity and cost effectiveness are literally extraordinary. But we need to increase the rate of dissemination, or we will not see significant change in our lifetimes.

That would be very sad when we have the tools available to us. We simply need the support and the incentive to see that happen, even our own institution, while it gains 97 percent of its operating funds from the private sector. The National Science Foundation, in funding, as part of an overall exhibition valued at $1.6 million on space exploration, including a component of a simulated mission to Mars—the NSF piece of that was only $650,000. So the Federal incentive effort that drives the partnerships that can now, through section 4, drive the transfer of quality programs and exhibitions across the country can really gain extraordinary returns and improve the quality of science literacy across the country.

Mrs. MORELLA. Thank you.

Dr. Wint or Ms. Levine?

Ms. LEVINE. I would just like to add that we, as a small center, get tremendous support in terms of good advice and plans for exhibits, if we ask for them, from the large centers.

Mrs. MORELLA. Do you have to ask for them or do they have a communication besides regular newsletters?

Ms. LEVINE. There isn't an automatic communication, but through the ASTC newsletter and through the yearly meetings, we know what's going on, and we have personal contacts with people in a variety of other museums, so that we have no problem getting information or advice. But we don't have the financial support to implement that.

There is tremendous sharing. Never have we ever met up with anyone—

Mrs. MORELLA. It sounds to me also like you're pretty motivated.

Ms. LEVINE. Yes, and everyone is motivated by the same forces.

Mrs. MORELLA. Dr. Wint?

Dr. WINT. I think there's an interesting element that was raised, and that is, as an institution develops a very successful program, like in St. Louis, we developed the science park, the first science park of its kind in the United States, funded by NSF, we had a tremendous amount of interest. As was mentioned, we did a workshop on that; we provide plans for cost. We're doing another half-day workshop in the Fall. There's a tremendous expense also associated with the host institution.

Mr. Buechner asked if there were any other ways we could do it. Somehow to in a modest way return at least the staff expense that an institution has to convey is, in a sense, spending to all these visitors who are coming. Because at some point you say, we just can't do our own work anymore. We have so many folks coming and looking at this new exhibit.

There are a couple of other things that I think may be worth considering, based on Mr. Buechner's question, and one is the urban initiative that NSF is talking about. If we really are going to include more underrepresented audiences, particularly African-Americans and Hispanics, in science, they're going to come from the urban areas, and I think NSF's proposal to do that is a very important one.

I see personally a tremendous need for training of professionals in science museums. With this explosion of growth, how are we going to have the appropriately trained people in order to run our institutions? And very much of a part of that are, again, underrepresented audiences.

And also, we've been very successful at a limited number of consortia, consortia to build exhibits which are then shared by a group of six or eight or ten institutions. But often that one consortia can only serve those members, and there are whole groups of other institutions that are outside the consortia. So more consortia funding, I think, would be very beneficial to us.

Mrs. **Morella**. Do you have a difficulty with the salaries or remuneration for the personnel that you talk about that you need greatly on that level?

Dr. **Wint**. Almost daily.

Mrs. **Morella**. Congressman Buechner represents your area very well. He told me to say that. No, he didn't.

Thank you, Mr. Chairman.

Mr. **Valentine**. Yes, he does, indeed. So does Mr. Boehlert and Connie and everybody.

I know we've got to move along, but I just want to ask one last question of the panel, a matter of some interest. Are any of the institutions that you represent connected in any way with other local institutions for example, Dr. Wint, the fabulous St. Louis Zoo. And in your situation, Dr. Krakauer, is there any connection between your institution in the North Carolina School of Math and Science?

Dr. Wint?

Dr. **Wint**. Yes, very much so. The Science Center, St. Louis Zoo, and the Missouri Botanical Garden have a very close relationship. Three institutions all devoted to informal science education. This Fall, we will produce for the first time one common educational brochure for elementary school to show that, in fact, it's not an issue of one institution's educational program, it's a joint effort of science education in a totality.

In January of 1992, the Science Center will open the rain forest exhibits circulated by the Smithsonian that is co-sponsored by also the Zoo and the Missouri Botanical Garden. And we are a part of the NSF project at the University of Missouri, St. Louis, that is a career-oriented program for underrepresented audiences. And I believe we're the only science cultural institution that's in that consortium with the University of Missouri, St. Louis.

Those are only a couple of the kinds of things that we do. We are really quite broadbased, including relationships with organizations such as Sigma XI and the American Chemical Society, in which we provide an important service or role with them as well.

Mr. **Valentine**. Mr. Shafer?

Dr. **Krakauer**. We've got a good relationship with North Carolina School of Science and Math. We use a lot of their students as volunteers and work on programs at the museum, and we are tying down the details for a major new initiative with the public schools to help revamp the public school curriculum, where we will be working extensively with them. And, as Dr. Wint also mentioned, we work very closely with groups such as AAAS and Sigma XI in trying to link scientists and engineers to assist classroom instruction.

Mr. **Valentine**. Mr. Shafer?

Mr. **Shafer**. Mr. Chairman, our institution not only partners with local not-for-profit groups, like our zoo, but also with the formal education institutions across the State of Ohio. We host with the State Department of Education an annual science conference for teachers and curriculum folks from across the State of Ohio, and also presently I am chairing the State-wide Commission on Science and Math that will be developing a plan for science and math education for Ohio into the next century. So our involvements are very well-integrated across Ohio with public and private schools.

Mr. **Valentine**. Thank you.

Ms. Levine?

Ms. **Levine**. We do link first with the educational institutions in our community, and we also have an organization called the Natural History Network, which involves all the not-for-profit organizations in the region that are even remotely interested in science education. And we meet every two or three months to share ideas, and we sometimes cooperate in events. We'll have a joint event.

Mr. **Valentine**. Thank you very much.

Thank all of you very much for the preparation that went into these presentations and for being here with us.

We'll hear now from the third panel, which consists of Mr. Dallas Garrett and Dr. Jack B. Evett.

Welcome, gentlemen. Your prepared statements will appear in the record as presented to us, and I would request that you summarize.

Mr. Garrett?

STATEMENT OF DALLAS GARRETT, DEAN FOR BUSINESS, HEALTH AND TECHNOLOGY, CENTRAL PIEDMONT COMMUNITY COLLEGE, CHARLOTTE, NORTH CAROLINA

Mr. **Garrett**. Thank you. We are certainly pleased to be here, Mr. Chairman. The American Association of Community and Junior Colleges and the Association of Community College Trustees have asked to be associated with the testimony I'm giving today. I spent a fair amount of time talking with them over the weekend and in preparing some of my statements.

Among all the challenges and problems facing American education today, viewed in terms of global competitiveness, none is more serious than the glaring lack of articulation, generally among institutions and systems of higher education. The problem is pervasive between community and technical colleges and the four-year colleges and universities public and private.

It is perhaps most injurious to the national interest in the various fields of science, engineering and technology. In the terms of global competition, the problem has been aptly defined as the pipeline problem.

Mr. Chairman, members of the subcommittee deserve a world of credit, starting with the former chair, Mr. Walgren of Pennsylvania, and his National Advanced Technician Training Act, for the attention you have been giving to this issue in recent years. You were focusing public attention on this need long before the Executive Branch began to talk about it.

We hope you will take what is proposed in the Walgren, Price and Mikulski bills and build them into a comprehensive two-prong program that both doubles the funding for the National Science Foundation and involves it heavily in pipeline initiatives. One prong of the program should be the NSF support of the industry-college partnerships envisioned in the Walgren-Mikulski bills.

Let me illustrate the importance of such partnerships in terms of my own State. The availability of technicians to staff the factories of the future, as well as the present automated workplaces, is severely limited. We consider the State of North Carolina very progressive in the advanced technologies yet we must advertise out of State on a routine basis to staff our high tech positions. We consider this pretty sad.

We are very much in need of model instructional programs in the advanced technologies, such as computer-aided design, computer-aided manufacturing, computer-integrated manufacturing, and the list goes on. The expanded training that H.R. 1720 wouid provide, keyed to the skill shortage of high tech industries, would hasten the development of such model to the great benefit of all education.

We have established two advanced technology centers in North Carolina for the purpose of attacking this problem. These centers have formed numerous partnerships that have yielded millions of dollars worth of hardware and software, but there are always gaps in fixturing, tooling, software, sensing and integration. It requires significant commitment from grants to survive.

Upgrading of faculty is a key issue today and will continue to be a major issue in the future. It's been very difficult to recruit experienced people from industry, and therefore it is essential that we develop and fund faculty upgrade and retraining programs.

Better laboratory hardware and software is of critical importance to all two-year and four-year advanced technology programs, and without industry partnerships and major grants, we will not be able to establish model programs. H.R. 1720 and H.R. 3122 would increase the colleges' and faculties' access to state-of-the-art equipment and software.

Another significant problem is the lack of emphasis on hands-on occupational experiences at the high school level in advanced technologies so that students understand the reason for math and science instruction and develop an understanding and appreciation for the advanced technologies and their future needs.

We see the community college as the ideal conduit between high school, 4-year college, and industry. The student who chooses the community college track after high school has outstanding options. We find that approximately 10 percent of our graduates go on to 4-year programs immediately, and, by the way, in engineering technologies, that percentage is 16—I quoted 10 percent as the entire college, 16 percent in the engineering technologies. And I just got new statistics today—and most of them go on to UNCC, and the remaining students enter the workforce in their chosen field or a related field at an 85 percent rate. That is, 15 percent go out into something that we didn't train them for.

The development of model centers is an excellent idea, and we're very much aware of the need to develop instructional materials for students at all levels. The establishment of two-year, four-year partnerships is something we have accomplished in North Carolina, but this concept could certainly be expanded and improved.

We see a great need for more students interested in math, science, the advanced technologies, and the establishment of a grant program to assist students would be very beneficial. The Advanced Technologies Center at Central Piedmont Community College in Charlotte, where I happen to be the Dean, will open this month. It's a $4.5 million facility, and we will have approximately $10 million worth of state-of-the-art hardware and software when we open that facility. And we will have purchased none of that equipment. We will need another half a million or a million or so to make that equipment operational. We think partnerships are the key, and this is how we bring in the hardware. We won it on consignment, not even donated.

The second problem of your solution, we respectfully suggest, should address the articulation problem directly. Through the NSF, incentives should be provided to encourage the better engineering schools and science departments in the four-year institutions to develop both formal articulation agreements and instructional partnerships with the two-year colleges in their service regions.

Under this approach, the NSF would make matching grants to consortia of such schools for the primary purposes of improving instruction in these fields on the lower division level and increasing the flow of science and engineering majors, particularly women and minorities, from the community and technical colleges into the senior institutions.

Neither NSF nor the country can afford to ignore the fact that more than half the Americans entering higher education are in community colleges, and this proportion continues to grow. I probably don't need to explain that I left my glasses in my darn bag, and it's back in the hotel. I'm struggling a little bit.

In conclusion, Mr. Chairman, if our country is to compete in the global marketplace, it must build a better class workforce, one that is competitive across a broad spectrum of technological and industrial change, and we must build it quickly. Time is running against us, and we lose more and more high tech jobs to producers in other lands.

Every $10 billion increase in the trading deficit means we have exported thousands of manufacturing jobs and replaced them with mostly low-paying service jobs. Industry, government, education, labor, small business and the general employer community all must accept responsibility for this challenge. All of us must pull together toward a cohesive national strategy for human resource development, and the NSF must play a very central role. Thank you.

[The prepared statement of Mr. Garrett follows:]

Testimony

to the

Subcommittee on Science, Research, and Technology
U.S. House of Representatives

by

Dallas Garrett, Dean
Business, Health, and Technology Programs
Central Piedmont Community College
Charlotte, North Carolina

June 14, 1990

Mr. Chairman, the American Association of Community and Junior Colleges and the Association of Community College Trustees have asked to be associated with the testimony I am giving today.

Among all the challenges and problems facing American education today, viewed in terms of global competitiveness, none is more serious than the glaring lack of articulation generally among institutions and systems of higher education. The problem is pervasive between community and technical colleges and the four-year colleges and universities, public and private, and it is perhaps most injurious to the national interest in the various fields of science, engineering, and applied technology.

In terms of global competition, the problem has been aptly defined as the "pipeline" problem. President Bush's FY'91 budget defines it this way:

> "The 'pipeline' of young people that feeds the S&E workforce may not be adequate in either numbers or quality to provide the workers that will be needed during the next decade and beyond. Between 1980 and 2000, the number of 18-24 year olds will decline by 19 percent while the overall population will increase by 18 percent. Even if the historic average holds, and five percent of 18-24 year olds obtain S&E degrees, the resulting shortfall in the S&E workforce could reach into the hundreds of thousands. Moreover, many students with an expressed interest in science and engineering careers leave the pipeline before getting a degree in science and engineering. This is particularly true for underrepresented minorities. Currently Black and Hispanic children constitute 25 percent of our school children; by the year 2000 this percentage will rise to 47 percent. Yet it is these groups that are now the most underrepresented in the S&E workforce: in 1988, only 231 Black and Hispanic Americans earned doctorates in science or engineering fields (excluding psychology or the social sciences). Together, Black and Hispanic Americans constitute 20 percent of the nation's population, but only four percent of employed scientists and engineers."

Mr. Chairman, members of this Subcommittee deserve a world of credit, starting with the former chair, Mr. Walgren of Pennsylvania, and his National Advanced Technician Training Act (NATTA), for the attention you have been giving to this issue in recent years. You were focusing public attention on this need long before the Executive branch began to talk about it.

We hope you will take what is proposed in the Walgren, Price, and Mikulski bills and build them into a comprehensive two-pronged program that both doubles the funding for the National Science Foundation and involves it heavily in "pipeline" initiatives.

The endangered states of American leadership in industry, science, and technology are all closely linked, and traceable in part, I believe, to NSF's long-term neglect of undergraduate education in general and community colleges in particular.

One prong of the program should be the NSF support of the industry-college partnerships envisioned in the Walgren-Mikulski bills. Let me illustrate the importance of such partnerships in terms of my own State.

The availability of technicians to staff the "Factories of the Future" as well as the present automated workplaces is severely limited. We consider the State of North Carolina very progressive in the Advanced Technologies, yet we must advertise out of state on a routine basis to staff our high tech positions.

We are very much in need of model instructional programs in the Advanced Technologies such as: Computer Aided Design, Computer Aided Manufacturing, Computer Integrated Manufacturing, Computer Repair, Microelectronics, Laser/Electro-optics, Machine Tool Repair, Quality Assurance, Textile Automation, Modern Furniture Manufacturing, Computer Engineering Technology, and many other Advanced Technology careers. The expanded training that H.R. 1720 would provide, keyed to the skill shortages of high-tech industries, would hasten the development of such models, to the great benefit of all education.

We have established two Advanced Technology Centers in North Carolina for the purpose of attacking this problem. These centers have formed numerous partnerships that have yielded millions of dollars worth of hardware and software, but there are always gaps in fixturing, tooling, software, sensing, and integration that require a significant commitment from grants to survive.

Upgrading of faculty is a key issue today and will continue to be a major issue in the future. It has been very difficult to recruit experienced people from industry and therefore it is essential that we develop and fund faculty upgrade and retraining programs.

Better laboratory hardware and software is of critical importance to all two-year and four-year Advanced Technology Programs, and without industry partnerships and major grants, we will not be able to establish model programs. H.R. 1720 and H.R. 3122 would increase the college's and faculty's access to state-of-the-art equipment and software.

Another significant problem is the lack of emphasis on hands-on occupational experiences at the high school level in the Advanced Technologies so that students understand the reason for math and science instruction and develop an understanding and appreciation for the Advanced Technologies and their future careers.

We see the community college as the ideal conduit between the high school, four year colleges, and industry. The students who choose the community college track after high school have outstanding options.

We find that approximately ten percent of our graduates go on to four year programs immediately, and the remaining students enter the work force in their chosen field or a related field at an 85 percent rate.

The development of model centers is an excellent idea and we are very much aware of the need to develop instructional materials for students at all levels.

The establishment of two/four year partnerships is something we have accomplished in North Carolina but this concept could certainly be expanded and improved. We see a great need for more students interested in math, science, Advanced Technologies, and the establishment of a grant program to assist students would be very beneficial.

The Advanced Technologies Center at Central Piedmont Community College in Charlotte, North Carolina will open this month. The 4.5 million dollar facility will house ten million in equipment within the first year and much of this equipment will come as a result of partnerships we have developed.

We expect to enroll in excess of 40,000 seats during the next twelve months in credit and non-credit Advanced Technology courses.

We could not maintain the level and quantity of hardware and software needed in this facility without major support from business, industry and grants of all kinds.

The second prong of your solution, we respectfully suggest, should address the articulation problem directly. Through the NSF, incentives should be provided to encourage the better engineering schools and science departments in the four-year institutions to develop both formal articulation agreements and instructional partnerships with the two-year colleges in their service regions.

Under this approach, the NSF would make matching grants to consortia of such schools, for the primary purposes of improving instruction in these fields on the lower division level and increasing the flow of science and engineering majors, particularly women and minorities, from the community and technical colleges into the senior institutions. Neither NSF nor the country can afford to ignore the fact that more than half the Americans entering higher education are in community colleges, and this proportion continues to grow.

Mr. Chairman, we have worked with the AACJC and the ACCT on draft language for this concept, which we respectfully offer in the hope that it may aid you in the development of your legislation.

In conclusion, Mr. Chairman, if our country is to compete in the global marketplace, it must build a world class workforce, one that is competitive across the broad spectrum of technological and industrial change. And we must build it quickly. Time is running against us, as we lose more and more high-tech jobs to producers in other lands. Every $10 billion increase in the trade deficit means we have exported thousands of manufacturing jobs and replaced them with mostly lower-paying service jobs. Industry, government, education, labor, small business, and the general employer community all must accept responsibility for this challenge. All of us must pull together toward a cohesive national strategy for human resource development, and the NSF must bear a very central role.

SCIENCE EDUCATION BILL

Comments By: Dallas Garrett, Dean
Business, Health, and Technology Programs
Central Piedmont Community College
Charlotte, NC 28235

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The upgrading of laboratory hardware and software is of critical importance to all two year and four year Advanced Technology Programs and without industry partnerships and major grants we will not be able to establish model programs.

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We could not maintain the level and quantity of hardware and software needed in this facility without major support from Business, Industry, and Grants of all kinds.

Respectfully Submitted,

Dallas Garrett

Dallas Garrett, Dean
Business, Health, and Technology Programs

ds

PROFESSIONAL VITA
DALLAS GARRETT 342-6909

ADMINISTRATIVE EXPERIENCE

1989 - Present	Central Piedmont Community College Charlotte, North Carolina Dean, Business, Health & Technology
1987 - 1989	Daytona Beach Community College Daytona Beach, Florida Dean, School of Technologies
1985 - 1987	Triton College River Grove, Illinois Dean of Business and Technology
1983 - 1985	Lorain County Community College Elyria, Ohio Division Chariman, Engineering Tech. and Computer Science, CAD/CAM, CNC, Robotics, Microelectronics, Computer Systems, Computer Science

TEACHING EXPERIENCE

1967 - 1983	Washtenaw Community College Ann Arbor, Michigan Instructional Coordinator and Numerical Control Instructor
1962 - 1967	Saline Area Schools Saline, Michigan Machine Tool Instructor and Department Chairperson

RELATED WORK EXPERIENCE

1967 - 1968	Buhr Machine Tool Ann Arbor, Michigan Supervisor of Apprentices, Toolmakers, Machine Builders, N/C Machinist (Part-Time)
1960 - 1962	Wayne State University Audio Visual Technician
1956 - 1959	Storch Products Detroit, Michigan Draftsman - Gage, Jig and Fixture Design, Prototype Machinist, Mold Maker

EDUCATION

Highland Park Junior College
Highland Park, Michigan
Engineering, 1956-1958

Wayne State University
Detroit, Michigan
B.S., Industrial Education, 1962

Eastern Michigan University
Ypsilanti, Michigan
M.A. Educational Administration, 1966
Educational Specialist Degree, 1966-1969
Vocational Education, 28 hours completed

CONSULTING

Primary Consultant for over 20 Advanced Technilogical Centers in the past 10 years.

Mr. **Valentine**. Thank you, sir.

Dr. Evett?

STATEMENT OF DR. JACK B. EVETT, ASSOCIATE DEAN, COLLEGE OF ENGINEERING, UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE, CHARLOTTE, NC

Dr. **Evett**. Thank you, Mr. Chairman. I do want to thank you very much for the opportunity to appear before this subcommittee today. I have been asked to comment on subsection 5(e), and I will limit my comments to that subsection.

Subsection 5(e) seeks to increase the number of students graduating with baccalaureate degrees in mathematics, science, and engineering technology by strengthening the associate degree granting college to a four-year academic institution pipeline. I think this is an admirable objective and has the potential to significantly increase the number of such graduates, an objective we all recognize as being much needed.

My institution, the University of North Carolina at Charlotte, receives approximately half of its students as transfers, many from two-year institutions. We feel that, on average, they perform as well as or better than students who matriculate as freshmen, and this provides a relatively inexpensive way for students to complete their first two years of study at an associate degree granting college within commuting distance of their homes.

This is particularly beneficial in a State like North Carolina, where the three State-supported engineering schools are all located in urban areas—Charlotte, Greensboro, Raleigh—while many potential students are reared in distant rural areas of the State.

We also feel that a two-year institution can provide a buffer or transition between high school and the four-year university which can be helpful for some students, particularly for some minority students. Accordingly, I support the provisions of subsection 5(e).

I believe the engineering schools of North Carolina have already addressed to some extent parts i, ii and iii of subsection 5(e)(2)(D) very positively, and I would be glad to elaborate on these if you wish. There are, however, two areas where I would suggest some additional consideration be given.

One is that the proposed bill concentrates on encouraging students who are already attending a two-year school to go on to further study at a four-year institution. I would suggest some special emphasis on the initial recruiting of students into the associate degree granting colleges. We at the four-year academic institution attempt to recruit students from the associate degree granting colleges, but we are limited to contacting students who are already there. We cannot very well go out and recruit potential students, for example, graduating high school seniors, to go directly into the 2-year school.

I presume the two-year schools do recruiting, but my guess is that many do not make a concerted effort to recruit large numbers of students into pre-engineering with subsequent transfer to an engineering school as part of an overall package. I suspect that a significant number of capable individuals who live away from major urban and industrial areas are never made aware of the opportunities in science and engineering technology careers.

Another consideration in this regard is that there are two different tracks available at many two-year schools, one for students to transfer into an engineering program at the 4-year university, the other to track into an engineering technology program. These are distinctively different programs and are not interchangeable. A student completing the 2-year program in engineering technology cannot transfer to an engineering program and vice versa.

Since we have both programs at UNC Charlotte, we sometimes get transfer students who are in one program at the 2-year school but wanted the other one at UNC Charlotte, or else they were just not aware there was any difference. Therefore, I think it is very important that students get good advising at the time they are recruited and admitted to a 2-year school.

Here again, we at the four-year university cannot do this advising at that level. It must be done by the two-year school. So my first suggestion would be some emphasis on the recruiting and initial advising into the two-year programs.

The other area where I would suggest some additional consideration concerns the potential impact on actual numbers of students. As I understand the draft bill, a grant would be made to an individual two-year school, and it would then be able to develop a partnership with up to four four-year institutions.

This might be fine in a State having a small number of large two-year schools, but in North Carolina, which has a large number of two-year schools, with many of them being relatively small, this might not be as helpful. In other words, we depend on getting a handful of transfer students from each of a number of small schools. If such a small school received one of the proposed grants and was able to, say, double its output of transfer students to an engineering school, the impact on engineering enrollment would not be very great because of the small number to begin with.

Perhaps provision could be made for several—perhaps a maximum of four—small neighboring two-year schools to receive a grant and work together in carrying out a common goal of increasing the number of transfer students to one or more 4-year institutions.

I appreciate the opportunity of submitting this statement and hope that it will be of assistance to the subcommittee.

[The prepared statement of Dr. Evett follows:]

WRITTEN STATEMENT ON DRAFT SCIENCE EDUCATION BILL

Prepared for the Subcommittee on Science, Research and Technology
United States House of Representatives
by
Jack B. Evett, Associate Dean
College of Engineering
The University of NC at Charlotte
Charlotte, NC 28223

June 6, 1990

I am pleased to present this written statement at the invitation of Congressman Valentine on the draft science education bill.

The University of North Carolina at Charlotte (UNCC) is one of 16 constitutient institutions that comprise the University of North Carolina system. Approximately half of our students enter UNCC as transfer students -- many from 2-year institutions. The College of Engineering offers programs in both engineering and engineering technology as well as computer science. Thus, we are experienced in "helping students to transition from associate-degree-granting colleges to 4-year academic institutions to enable such students to achieve bachelor degrees in mathematics, science, engineering, or technology," which is the major thrust of Subsection 5 (e) of the draft bill, the part of the draft bill we were specifically asked to review and comment on.

It is clear from SECTION 2 of the draft bill that Congress is well aware of the urgent need to increase the number of graduates of scientists, engineers, and science, mathematics, and technology teachers in America. We feel the associate-degree-granting college to 4-year academic institution pipeline has potential to significantly increase that number, particularly with regard to females and minorities. The state of North Carolina has a comprehensive network of associate-degree-granting colleges, and, during its 25-year history as a university, UNCC has received many students from these 2-year colleges. We feel that, on average, they perform as well as or better than students who matriculate as freshmen; and they provide a relatively inexpensive way for students to complete their first two years of study at an associate-degree-granting college within commuting distance of their homes. This is particularly beneficial in a state like North Carolina where the three state-supported engineering schools are all located in urban areas (Charlotte, Greensboro, and Raleigh), while many potential students are reared in distant rural areas of the state.

To facilitate such transfer from 2-year colleges to the state-supported engineering schools in North Carolina, the University of North Carolina system established in 1984 a Subcommittee on Engineering Transfer. This subcommittee is comprised of three assistant or associate deans -- one from each engineering school (NC State University at Raleigh, NC A & T State University at Greensboro, and UNCC). It meets periodically and reviews 2-year pre-engineering curricula from any 2-year or 4-year institution requesting such a review. If an institution's curriculum is approved by the Subcommittee, then graduates from that program are assured of the transferability of appropriate courses into any of the three engineering schools. Such graduates are also given preferential consideration with regard to admission to an engineering school. The Subcommittee also meets from time to time with representatives from the institutions having approved programs for the purpose of briefing persons at the 2-year schools on specific requirements of courses at the engineering schools.

Accordingly, I believe the engineering schools of North Carolina have addressed (i), (ii), (iii) of Subsection 5(e)(2)(D) very positively, and we are, of course, willing and eager to share whatever we have learned with anyone else. However, we have done little to address (iv), (v), (vi), (vii), and (viii) of Subsection 5(e)(2)(D), although it is possible that some of the 2-year schools may have addressed some of these. I believe all of the provisions of Subsection 5(e) are very positive and should contribute significantly to increasing the output of science and engineering graduates via the associate-degree-granting college to 4-year academic institution pipeline, and I endorse them all very strongly.

There are, however, two areas where I would suggest some additional consideration be given. One is that I would like to see some special emphasis on the initial recruiting of students into the associate-degree-granting colleges. We at the 4-year academic institution attempt to recruit students from the associate-degree-granting colleges, but we are limited to contacting students who are already there. We cannot go out and recruit potential students (for example, graduating high school seniors) to go directly into the 2-year school. I presume the 2-year schools do recruiting, but my guess is that many such schools do not make a concerted effort to recruit large numbers of students into pre-engineering with subsequent transfer to an engineering school as part of a "package." I suspect that a significant number of capable individuals who live away from major urban and industrial areas are never made aware of the opportunities in science, engineering, and technology careers.

Another consideration in this regard is that there are two different tracks available at many 2-year schools--one for students to transfer into an engineering program at the 4-year university, the other to track into an engineering technology program. These are distinctively different programs and are not interchangeable. A student completing the 2-year program in engineering technology cannot transfer to an engineering program and vice versa. Since we have both programs at UNCC, we sometimes get transfer students who were in one program at the 2-year school but wanted the other one at UNCC, or else they were just not aware there was any difference. Therefore, it is very important that students get good advising at the time they are recruited and admitted to a 2-year school. Here again, we at the 4-year university cannot do this advising at that level. It must be done by the 2-year school.

The other area where I would suggest some additional consideration concerns the potential impact on actual numbers of students. As I understand the draft bill, a grant would be made to an individual 2-year school and it would then be able to develop a partnership with up to four 4-year institutions. This might be fine in a state having a small number of large 2-year schools; but in North Carolina, which has a large number of 2-year schools with many of them being relatively small, this might not be as helpful. In other words, we depend on getting a handful of transfer students from each of a number of small schools. If such a small school received one of the proposed grants and was able to double its output of transfer students to an engineering school, the impact on engineering enrollment would not be very great because of the small number to begin with. Perhaps provision could be made for several (maybe a maximum of four) small neighboring 2-year schools to receive a grant and work together in carrying out a common goal of increasing the number of transfer students to one or more 4-year institutions.

I appreciate the opportunity of submitting this written statement and trust that it will be of assistance to the Subcommittee.

JACK B. EVETT

Associate Dean of Engineering
Professor of Civil Engineering
The University of North Carolina at Charlotte

Education:
B.S. Civil Engineering (Cum Laude), University of South Carolina, 1964
M.S. Civil Engineering, University of South Carolina, 1965
Ph.D Civil Engineering, Texas A & M University, 1968

Registration:
Professional Engineer, NC No. 6393, SC No. 5257
Land Surveyor, NC No. L1740, SC No. 5257
Notary Public, NC

Employment:
The University of North Carolina at Charlotte

1982 to date	Associate Dean of Engineering
1981 to 1982	Acting Dean of Engineering
1977 to 1980	Assistant to the Dean of Engineering
1973 to 1975	Assistant to the Dean of Engineering
1983 to date	Professor
1973 to 1983	Associate Professor
1967 to 1973	Assistant Professor

Publications:

Author or co-author of seven text books and one problems book with four more currently in various stages of production; author of two articles in science and technology encyclopedias and of a chapter in a surveying handbook; author or co-author of four research-related papers and 25 education-related papers.

Theses:
Served on eight M.S.E. committees

Professional and Honorary Societies:
American Society of Civil Engineers
American Society for Engineering Education
Society of Sigma Xi
North Carolina Society of Engineers
Charlotte Engineers Club

Honors and Awards:
Election to Phi Beta Kappa
Tau Beta Pi
Pi Mu Epsilon
Service Award from NC Delta Chapter of Tau Beta Pi, 1981, 1987

Areas of Specialization:
Hydraulics, hydrology, surveying.

12/89

Mr. **Valentine**. Well, I thank both of you very much for preparing yourselves and for these presentations here today. We had contacted Congressman McMillen, but he was not able to be here today. We thought he would want to come and be a part of this proceeding, although he is not a member of the Science Committee, of course.

Let me ask you this question of either one of you or both of you. Do you believe that the draft bill includes the right kind of provisions to help increase the numbers of two-year college students transferring to four-year colleges in the fields of science and engineering?

Mr. **Garrett**. Well, the bill is not real specific. I mean, it talks about improving articulation, and, you know, improving those communication links would certainly help. How that is implemented, I think, how people write their proposals and submit them, will be of critical importance.

I will say that I am working on a much expanded recruiting plan, myself, at Central Piedmont. Our penetration, for example, is only 14 percent. In our own district, 14 percent of the high school graduates come directly to us at the community college. I'm aware of systems where that number is 50 percent. Rock Valley, for example, in Rockford, Illinois, is 50 percent.

We need to improve our penetration. We need to improve our communications at that level. And then, I just received this this afternoon. Between 1985 and 1990, we've had 611 engineering technology graduates; 121 of them have transferred. That seems like a pretty healthy number, but when you realize we serve 50,000 different students per year and have actually dropped from 55,000 to 50,000 over the last 4 or 5 years—we expect that to head up again—the impact just isn't very significant.

Charlotte is now—and these are new statistics—the number one manufacturing city in the United States. You can pick the 10 largest manufacturing cities, and Charlotte is number one. So, you know, there are implications that indicate that we really need to do our work.

Mr. **Valentine**. You mean, Mr. Garrett, based on population or the ratio? Certainly, there's not more manufacturing there than in——

Mr. **Garrett**. Percentage. Number one in the Nation in manufacturing as a percentage of the total workforce.

Mr. **Valentine**. OK.

Mr. **Garrett**. We're 29 percent. I think Chicago's 18 right now.

Mr. **Valentine**. Let me ask you a question. I should know the answer to this, but if I did, I wouldn't ask you. The community college that you're connected with, Central Piedmont Community College, as well as all other community colleges in North Carolina, do not offer, do they, a 4-year program?

Mr. **Garrett**. That's true. It's 2-year.

Mr. **Valentine**. So when you speak of 2-year institutions, you're talking now, at least in that State, mostly with community colleges and technical institutes, aren't you? Because the Mars Hills have become 4-year colleges and the Louisburg College, and there are very few of those private, church-related institutions left that are 2-year colleges.

Mr. Garrett. That's true.

Mr. Valentine. Now, do either one of you have any statistical information that gives any indication of how other community colleges might fare in a program like this? You know, it's been my experience that if you want to become a nurse, you would go to this community college, at least in our State. If you wanted to be a good automobile mechanic, you would go to this. They don't all try to do the same thing. Is this just a special arrangement between the two of you in that area insofar as training in math and science?

Mr. Garrett. Well, I've, as you know, been the dean of four colleges all across the United States and have been employed in five different community colleges, all fairly comprehensive community colleges, and I have never seen the statistics any different than I've given you. They've all pretty much offered all of the programs, and the percentage of students in science, math, and engineering technologies is generally much lower than needed.

I guess I don't know what the reasons are, but I have my own opinions. I think we scare them away at a very early age because of our approach to teaching math and science. I think we teach it as a non-hands-on subject, and I think that hurts us. That hurts us very early.

Dr. Evett. Mr. Chairman?

Mr. Valentine. Yes, Mr. Evett?

Dr. Evett. I'm not sure I understood your question, but let me try and answer. I believe there are about 58 or so community colleges in the State of North Carolina. Of roughly half of those, we get transfer students into both our engineering program and our engineering technology program. We draw from around the State.

In engineering technology, we have essentially the only program of this type whereby all of the graduates, in fact, all of the students that come into our engineering technology program, come from 2-year schools. We do not have the first 2 years in engineering technology, and we have virtually the only program like that in the State, so we draw all over the State into our engineering technology program.

The other program, our engineering program, we also draw from the community colleges. We tend to draw a little bit more from the western part of the State because of location.

Mr. Valentine. Well, that is at least part of what I was asking. The other part of it is, the students that come to you from other institutions besides the Dean's college, do they fare as well as his students?

Dr. Evett. We generally find that students that transfer into our program generally do quite well. I don't have hard evidence to compare others versus his, but we are very pleased to get transfer students. I'll put it that way.

Mr. Valentine. Mr. Garrett, I believe you mentioned something about equipment which was in place at your institution, and I thought I understood you to say it didn't cost you anything.

Mr. Garrett. Any place I've ever been, I have always formed major partnerships, and we expect our partners to consign equipment. And we roll it over when their newest model comes out, and there is a good price for that. We have to provide whatever they need in training, and they get resumes from our students, and that's basically our partnership.

There is a complication always, and, you know, so many colleges choose to go the other route. Rather than commit to the kind of things that industries really need, they try to buy equipment, and they buy educational models. They buy a $100,000 system and never know how it was put together instead of a $10 million system and put it together themselves.

When we take on a project like this, we need that extra half a million or extra million, and it causes complications. We sometimes have to really scramble for the other half a million or million through grants and whatever to really put together the type of system that will best serve the needs of our school, students and educational system.

Mr. VALENTINE. Dr. Evett, have you seen a significant increase in student transfers from 2-year colleges since the establishment of the Subcommittee on Engineering Transferring in 1984?

Dr. EVETT. I don't believe so, but I think that's tied to the fact that overall enrollments in engineering have declined both at our school and at the national level. The engineering enrollments have been steadily declining since about 1983 or 1984.

Mr. VALENTINE. Mr. Buechner?

Mr. BUECHNER. I have no questions, Mr. Chairman. Thank you.

Mr. VALENTINE. Well, that's it. Thank you both very much.

Mr. GARRETT. Thank you for the opportunity.

Dr. EVETT. Thank you.

Mr. VALENTINE. We have got a vote, but I think I will ask panel number four to come on up, and we'll get started if you are ready. And we'll go for about five minutes perhaps. That's Mr. Allison and Ms. Stanion.

Welcome. As I stated to the other witnesses, your prepared statements will appear in the record as presented to us, and we would request that you summarize.

Mr. BUECHNER. Mr. Chairman, if I may, I would like to take the opportunity to personally welcome our two witnesses. Mr. Allison is from right on the edge of my district, and he served 32 years of fine service with the McDonnell Douglas Corporation, where he was the Director of Human Resource Services, and he's got an extensive background in employment, selection, training, development, and technology-based learning. He's got his own consulting company right now, and he has been a formidable force in working in so many areas of trying to put people and technology and learning and employment all together, and I just wanted to make that special word.

Also, Ms. Stanion here, the Director of Government Relations for the International Communications Industries Association, is a former representative in the Vermont House, and I just wanted to make that a part of the welcome to her.

Mr. VALENTINE. Thank you very much.

Mr. Allison?

STATEMENT OF THEODORE H. ALLISON, HUMAN RESOURCE CONSULTING SERVICES, FERGUSON, MI

Mr. ALLISON. Mr. Chairman, committee members, I'm very pleased to be able to respond to the request from the subcommittee to provide testimony on this draft science education bill. The subcommittee is to be commended for their effort in developing this bill.

I agree with and strongly support all of the programs that are being proposed in it; however, I would like to suggest that much more needs to be done. While many people in the United States have heard or know that a high percentage of young people graduating from high school are not prepared to go on to higher education or into the workforce, most people do not recognize that major improvements are needed in the educational system if the United States is to continue to provide world leadership and remain competitive in the world of trade.

In general, the changes required in the educational system must be made at the State and local level and will require the support of the general public. I do not believe this support now exists or will exist until Congress and the Administration makes educational reform a national issue, probably second in importance only to national defense.

One of the major changes that would help move the United States into improving the educational system would be through the use of technology-based learning systems. A large number of studies have been conducted by the military, by industry, and researchers on the use of technology-based learning, and most of these studies show that the learning process is greatly improved and, in many cases, the cost of providing the education can be reduced.

The systems appear to work for all types of students—the economically disadvantaged, the good student, the poor student, and for adults. You will also hear that many schools are now using computers in their classroom. In most cases, these computers, when you really talk to the schools and the teachers, the schools are using the computers more as typewriters or a calculating machine, spreadsheets; they're not using computers in the true sense of a technology-based learning system.

Mr. VALENTINE. Mr. Allison, that's the second bell. Let me ask you to please bear with us, both of you. We have another vote, and we'll get back just as soon as we can.

Mr. ALLISON. That will be fine.

[Recess.]

Mr. VALENTINE. Please proceed.

Mr. ALLISON. As I was about to say, many schools and teachers say that they are now using computers in their classrooms; but, in most cases, if you really check, they're using these computers as typewriters or word processors. They're not using them in the sense of a technology-based learning system.

I'd like to recommend then, to help overcome this lack of knowledge, that you consider two additional sections to your proposed bill. One, to establish a national institute for learning technology. This institute would be to stimulate public and private sector efforts toward enhancing the productivity of delivering basic education, advanced instruction, worker training/retraining through the application of technology-based learning systems.

The institute would collect, assess and diffuse data and information about the developments and the trends in technology-based learning. They would propose broad national goals for the productive use of technology-based learning. They would promote and encourage research into the broad policy issues concerning human interaction and the acceptance of technology-based learning. They would investigate policy options aimed at establishing a coordinated institutional framework for planning, conduct and the support of research and development done by the Federal Government, the private sector, and educational institutions in technology-based learning. Develop and assess policy options for improving the dissemination technology-based training information and know-how.

The second recommendation that I would like to make as an addition to the bill would be to establish a teacher orientation and retraining program. As most teachers today do not understand the use of technology-based learning systems, we must put something into place to retrain the present teachers.

The purpose of this program, then, would be to focus on learning systems strengthening the teachers in science and in mathematics at all levels of primary and secondary education. For this training to be effective, we have to move it out into the schools. We cannot set up a center in Washington or a center in St. Louis and expect to train teachers. We need to set up some type of a mobile training system where these mobile training classrooms then would be able to go around the country and retrain teachers on how to use all the latest technology that is now available to them.

To implement the two new sections that I am proposing, I would also recommend, to set up the institute, that section 8 of the proposed bill be changed to add $5 million for the institute, and to carry out the section on teacher training and retraining that $6 million be established as an appropriation to carry out that section of the bill.

I've attached two documents to my written statement which I hope the committee will consider. I think those two documents go a long way toward supporting the efforts of your committee in the proposals put forth in section 3 and section 5 of the proposed bill. One of them is a document from Dr. Branson from Florida State University, and the other one is a report from the U.S. Department of Commerce and an organization called SALT, the Society for Applied Learning Technology, on a study that they have done recently on technology-based learning.

I'd like to take the opportunity to thank you for asking me here, and I will try to answer any questions that you might have.

[The prepared statement of Mr. Allison follows:]

Human Resource Consulting Services

Prepared statement of Theodore H. Allison for
the Subcommittee on Science, Research and
Technology hearing on 14 June 1990, on a
Subcommittee draft science education bill.

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Human Resource Consulting Services

BIOGRAPHY

THEODORE H. ALLISON

After 32 years of service, he retired from McDonnell Douglas Corporation on 31 March 1988, where he was Director - Human Resource Services. He has an extensive background in employment, selection, training, development and technology based learning. At the present time he has his own Consulting Company (Human Resource Consulting Services). He is Chairman of a Federal-Private Sector Task Force on Productivity Improvement, a member of the U.S. Labor Department Round Table, a member of the Missouri School Board Association Technology Task Force and has participated in many conferences and focus groups on training and education of the American work force. He is a member of the Society for Applied Learning Technology and the American Society for Training and Development.

I am very pleased to respond to the request of the U.S. House of Representatives Subcommittee on Science, Research and Technology to provide testimony on a Subcommittee draft science education bill.

The Subcommittee is to be commended for their effort in developing this bill. I agree and support the programs being proposed. However, I would like to suggest that much more needs to be done. While many people in the United States have heard or know that a high percent of young people graduating from high school are not prepared to go on to college or into the work force, they do not recognize that major improvements are needed in our educational system if the United States is to continue to provide world leadership and remain competitive in the world of trade.

In general, the changes required in the educational system must be made at the state and local level; and will require the support of the general public.

I do not believe this support now exists or will exist until congress and the administration makes educational reform a national issue and second in importance only to the defense of this country.

One major change that would help move the United States into improving the educational system would be the use of technology based learning systems.

A large number of studies conducted by researchers, the military and private industry shows that the use of technology based learning systems improves the learning process and in many cases reduces cost. These systems appear to work for all types of students including adults, the economically disadvantaged, poor and good students.

Many schools and teachers say they are now using computers in their classrooms, but in most cases they are simply being used as typewriters (word processing) or preparing spreadsheets. This is not using technology as a learning system. In fact, by far most teachers, administrators and school board members have never seen, much less used, a technology based learning system.

To help overcome this lack of knowledge, it is recommended that two additional sections be added to the proposed bill:

Section xx Establishment of a National Institute for Learning Technology

(a) National Institute - The Director shall establish a National Institute for Learning Technology. The purpose of this Institute is to stimulate public and private sector efforts toward enhancing the productivity of delivering basic education, advanced instruction and worker training/retraining through the application of technology based learning systems.

(b) The institute is authorized and directed--

(1) to collect, to assess, and diffuse data and information about developments and trends in technology based learning throughout the world (including the efforts of foreign governments), to coordinate with other agencies involved in this field, and to develop, articulate, and recommend national policies regarding it:

(2) to propose broad U.S. national goals for the productive use of technology based learning, and for the preparation of citizens to benefit from the ability of this technology to provide lifelong learning:

(3) to promote and encourage research into the broad policy issues concerning human interaction with, and acceptance of, technology based learning systems in the home, the school, and the workplace:

(4) to examine and assess the potential impacts on regulatory structures of new technology based learning configurations, and to propose regulatory policy options, changes, or modifications responsive to new or novel applications of this technology:

(5) to investigate policy options aimed at establishing a coordinated institutional framework for the planning, conduct, and support of research and development done by the Federal Government, the private sector, and educational institutions in technology based learning/training systems:

(6) to develop and assess policy options for improving the dissemination of technology based training information and know how, with particular attention to coordinating activities among agencies and identifying institutional barriers to improved information flows:

(7) to carry out analyses of current and potential international technology based research, and to encourage and promote appropriate research on learning issues:

(8) to stimulate, and/or sponsor studies and pilot demonstration projects and to make recommendations aimed at the more efficient use of technology based learning software, courseware, and hardware to improve educational/training productivity within the Federal Government and/or the private sector:

(9) to develop channels of communications and promote extensive interaction between the Institute and appropriate governmental, educational, industrial, commercial, and other private entities. The goal is to promote innovation, to develop more efficient utilization of technology based learning systems, and to provide a public policy forum for informed citizen involvement in issues relating to this field: and

(10) to serve as a center of catalytic activism in planning and promoting policies and programs to enhance the greater application of technology based learning systems nationwide, and thereby to improve the competitive posture of the nation in worldwide markets.

(c) The Director is authorized, within the limits of available appropriations, to enter into grants, contracts, cooperative agreements, or other arrangements with whatever persons, organizations, countries, or other entities deemed useful to accomplish the purposes of this section.

Section yy Establishment of a Teacher Orientation and Retraining Program.

(a) Teacher Retraining - The Director shall establish a Teacher Orientation and Retraining program on the use of technology based learning systems focused on strengthening the teaching of science and mathematics at all levels of primary and secondary education.

(1) A minimum of ten mobile training centers will be established within one year after the date of enactment of this act.

(2) Each center will be equipped with technology based learning systems and software required to implement the program described in paragraph (a).

(3) Each center will be staffed by one trainer and one maintenance technician.

(4) A minimum of twenty teachers will be trained by each center each week for forty five weeks each year.

(5) A minimum of five additional mobile training centers will be added in 1991, 1992, and 1993.

(b) The Director is authorized to reimburse local school districts who have a student population of minorities and/or economically disadvantaged students which exceed 40% up to $200 for each teacher trained.

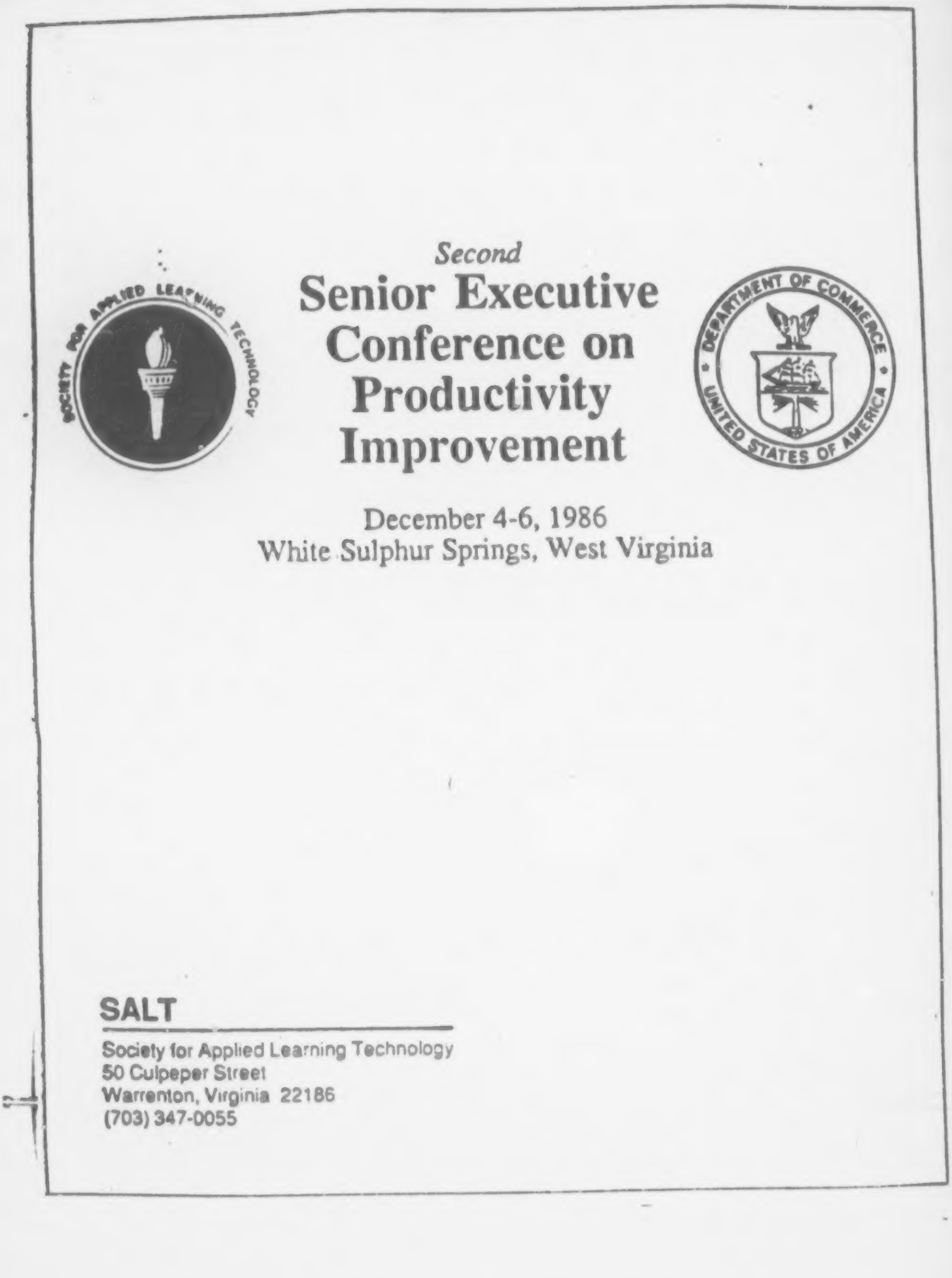
Modify section 8. Authorization of appropriations. Add two new paragraphs as follows:

(6) for carrying out section xx, $5,000,000 for fiscal year 1991 and such sums as may be necessary for subsequent fiscal years.

(7) for carrying out section yy, $6,000,000 for fiscal year 1991 and such sums as may be necessary for subsequent fiscal years.

Section 3 (d) of the draft bill appears to duplicate somewhat the Trade and Competitiveness Act subtitle B, sec. 6104. While this act was passed approximately two years ago, little or nothing has been done to promote or implement any programs to transfer information and/or software developed by or under the direction of Federal Agencies to public interest or commercial users.

Two documents are attached which support the purposes of Section 3, Section 5 and the proposed two new sections. The first report from Second Senior Executives Conference on Productivity Improvement - Incentives and Barriers to the Applications of Technology Based Learning sponsored by the U.S. Department of Commerce and the Society for Applied Learning Technology and second an article by Robert K. Branson, Director of Center for Educational Technology, The Florida State University.



Second

Senior Executive Conference on Productivity Improvement

DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA

December 4-6, 1986
White Sulphur Springs, West Virginia

SALT

Society for Applied Learning Technology
50 Culpeper Street
Warrenton, Virginia 22186
(703) 347-0055

Overview of Results, Findings, and Recommendations from the Senior Executive Conference on Technology Based Learning,
The Greenbrier, December 4-6, 1986

From December 4-6, 1986, 28 representatives from the private sector, government, and the educational community gathered at the Greenbrier Conference Center to examine "Incentives and Barriers to Applications of Technology Based Learning." The objective of this effort was:

To increase productivity in the United States via an integrated process for life-long learning through the application of technology to the learning process.

What follows is a summary of the meeting's findings and recommendations.

I. Conference Findings

The conference found that:

- Technology based systems improve learning
- Technology based learning is cost effective
- Labor-intensive educational methods alone are unlikely to enable us to achieve our national human resource productivity goals, therefore
- Technology based learning is necessary in achieving national life-long learning and reskilling objectives

II. General Recommendations

To enhance national productivity through the application of technology to education and retraining, the conference concluded that three major efforts should be mounted:

- Raising public awareness to the urgency of the problem and how technology might be brought to bear through a national initiative;
- Formalizing the collection and dissemination of information about currently available courseware and technology (perhaps via SALT);
- Actively seeking federal and state support for the application of technology based education and workforce retraining through current programs and/or through special legislation.

The conference suggested that task forces be created for each of these areas to support and to provide a focus for near term follow-up activities.

III. Recommendations for Action in Specific Areas

The conference's specific recommendations fall into the following four categories: Awareness; Basic Education and Life-Long Learning; Federal and State Activities; and Private Sector Initiatives. An overview of each category follows.

Awareness

Awareness has to do with raising the general public's and the education/training community's attention to the urgency of the education/training problem, and how technology can be brought to bear in solving it. Specific actions include:

- Mounting a public relations/education campaign via appropriate channels to educate teachers/trainers that technology based learning will make their jobs easier, and be a supplement to their regular programs, while stressing that technology based learning is not the answer to all education/training needs;
- Establishing a knowledge base (e.g., a clearinghouse) for technology based learning information and a similar knowledge base for courseware - including hardware, learning objectives, and quality evaluation;
- Seeking a memorandum of understanding (MOU), executive order, or legislation to establish such a clearinghouse if it is to be in the federal government;
- Creating an urgent demand for technology based training by demonstrating its effectiveness to opinion leaders and enlisting their support in spreading the word;
- Mounting a public relations campaign to highlight the critical need for qualified U.S. workers in meeting the nation's competitiveness challenge, and in promoting the utility of technology based learning in producing the needed skilled workers;
- Seeking actively to diffuse and coordinate the Greenbrier conference's findings and recommendations through other key public groups (e.g. the National Governor's Association);
- Encouraging courseware developers to publish/issue information with validated data in journals, at professional conferences, etc.;
- Disseminating information on good instructional design to fabricators via conferences, special courses, and specialized publications;
- Creating an appropriate environment in which sufficient funding will be generated to establish an accessible archive of audio/visual materials in the public domain;
- Producing a directory containing all hardware and courseware (by vendor) with compatibility specifications;
- Developing and presenting more case studies, testimonials, and pilot demonstration projects illustrating and validating the superiority of technology based learning for life-long training/retraining;
- Developing a mechanism whereby industry, government, and education can cooperate to arrive at new standards for technology based hardware and software;
- Identifying key "leverage points" in the educational community, and mounting a well-crafted campaign to encourage cost/benefit analyses proving the utility of technology based learning systems; and
- Providing data to show that technology based learning can register human experience as a storehouse of information available for immediate feedback in a learning situation.

Basic Education/Life-Long Learning

Major structural and administrative changes are needed to make public education/training more efficient and effective, and to change the emphasis from the allotment of time to the mastery of competencies. In this connection, the Greenbrier conference participants recommend the following initiatives:

- Determining methods of influencing the development of teacher training curricula so that alternative delivery systems (like technology based training) will be included, and seeking ways of influencing the current teaching population to accept, and to use alternative delivery systems;
- Accommodating learning styles and scope of content by changing the educational constant from time to the mastery of subject matter or skills;
- Mounting an educational campaign through appropriate public and private sector media channels on the advantages of technology based learning, the need to accommodate it in modern educational practices, and the fact that it will be extant for a long time to come;
- Improving instructional design to enhance flexibility in technology based learning systems;
- Instituting or encouraging the institution of cost management systems for technology in education to consider factors such as capitalization, depreciation, and amortization. In this connection, encouraging public and private education institutions to operate on cost systems that pinpoint relative costs to various models (e.g., comparisons between technology based systems versus traditional classroom methods);
- Encouraging the industrial trainer population to include alternative performance strategies and tools (e.g., technology based systems) in training programs;
- Mounting an information campaign aimed at the educational establishment on the advantages of technology based learning, the fact that it will be extant for a long time and the ways in which it works best in education (e.g., illustrating that present courseware needn't be scrapped);
- Defining industrial skills needed, and developing an inventory of curriculum items to meet those skill needs;
- In the K-12 area, defining an industry-driven core curriculum to meet national productivity needs, and developing quality measures to determine the best delivery systems;
- Establishing the "achievement of objectives" as the primary motive in educational input-output analysis;

Federal/State Activities

In advancing the cause of technology based learning systems, the conference finds that a needs exists for a state-federal partnership to be established in order for the following initiatives to be launched:

- Mounting an educational campaign through appropriate public and private sector media channels on the advantages of technology based learning and the fact that it will be extant for a long time;
- Providing federal financial incentives, such as investment tax credits, for the development of technology based learning resources, staff development, and capital acquisition;
- Providing federal funding equivalent to private sector investment incentives to public schools and non-profit educational institutions for the acquisition of technology based learning systems;
- Seeking public/private sector funding for research and/or demonstration projects to validate the efficiency of technology based learning;
- Promoting more interdepartmental coordination and communication by federal agencies, and stimulating a greater transfer of technology based federal learning systems to the private sector;
- Encouraging the installation of accounting systems in the Department of Defense and other federal agencies to show individual training costs and make visible the relative benefit- cost ratio of technology based systems;
- Forming user-developer consortia to plan, develop, and implement technology based training so that cooperative planning can ensure cost recovery over time and counter the perception that technology based learning costs are prohibitive;
- Establishing public/private sector funding for research and/or demonstration projects to validate the efficacy of technology based learning and/or its superiority over traditional types of training;
- Exploring the possibility of establishing federal guidelines to require data on relative instruction costs between traditional methods and technology based learning;
- Developing a strategy for changing the federal procurement classifications so that they are based on solid study data, and encouraging the installation of a more flexible multi-year procurement system for technology based learning systems;
- Promoting more inter-service coordination/communication

Private Sector Initiatives

The conference finds that the private sector has principal responsibility for authenticating the advantages of technology based learning and proving that it is faster, is more cost effective, and is universally applicable. To that end, the Greenbrier conference recommends that the private sector undertake the following initiatives:

- Creating consortia to seek grants, develop joint ventures, promote risk-taking, and establish libraries of materials;
- Establishing a knowledge base (i.e., a clearinghouse) for technology based learning information and one for courseware -- including information on hardware, learning objectives and quality evaluation;
- Forming user-developer consortia to plan, develop, and implement generic technology based learning so that cooperative efforts can ensure full cost recovery;
- Creating a private sector generated alliance between it, the federal government, and the educational establishment to obtain and fund technology based learning resources, staff development, and capital acquisition.
- Identifying or generating public/private sector funding for research and/or for pilot demonstration projects to validate the efficacy of technology based learning and/or its superiority over traditional types of training;
- Creating consortia to seek grants, joint ventures, and related partnerships and to establish libraries of technology based learning materials;
- Generating appropriate validated data to demonstrate clearly the increased productivity to be realized from technology based learning, again via pilot demonstration projects or courses.

Second Senior Executives Conference on Productivity Improvement
Incentives and Barriers to the Applications of Technology Based Learning

Background and Objectives

In cooperation with the United States Department of Commerce, the Society hosted a meeting in September 1985 to explore the issue of increasing productivity in the application of human resources, with particular emphasis upon the potential implementation of technology in the areas of education, training, and job performance. Productivity increases are a measure of the relative competitive capability of American industry compared with other industrial nations. Recently, the published 1985 productivity figures for manufacturing show the United States with a 2.8% increase, Japan, a 5% increase, West Germany, a 5.7% increase, and France, a 3.8% increase. In the services sector, the United States was reported to have a decline from the prior year, which meant that the overall productivity of the nation was basically flat. One of the critical factors in increasing productivity is effective utilization of human resources. A corollary is the effectiveness of human resource development specific to national goals.

In connection with this, education in the United States costs about $250 billion per year, including universities, public education, vocational and industrial training, and adult learning. It occupies 7% of the population and consumes 7% of the gross national product. It is estimated that at some point each year approximately 40% of the population is in an education or training program. About 25 million adults take some type of education or training, of which 60% is estimated to be job related. In addition, the Department of Defense spends approximately $13.4 billion a year on training its people in formal education settings.

Despite the expenditures and the admitted deficiencies in the quality and degree of training and education, applications of technology based learning systems are minimal in relation to potential benefits, which include reduced costs, increased learning and enhanced productivity. In contrast, it is clear that significant application of technology would result in corresponding gains in human resource development. It is also clear that the increasing applications base will expand the industry addressing this need.

A critical question arises as to whether there are barriers which can be reduced and incentives which can be increased in order to accelerate the implementation of technology based learning. In developing this topic, a group of representatives from the Society met with representatives of the Department of Commerce's Office of Productivity, Technology and Innovation, in order to seek informed comment on this subject and identify a way to bring the issues of incentives and barriers into focus and articulate potential methods for action to address these issues.

As a result, this conference will be a working forum to address these issues. The comments submitted have been summarized and will form the initial basis for the discussions. From this we expect to identify the critical issues with respect to these topics and formulate plans and specific activities needed to address each of the issues identified.

Why the Schools Can't Improve: The Upper Limit Hypothesis

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Introduction

The first purpose of this paper is to question whether there is a significant discrepancy between the current levels of productivity and quality of American schools and the levels required to serve the society well. The second purpose questions whether the current approach, or the approaches of blue ribbon commissions are likely to produce significant improvements. A third purpose sets forth the hypothesis that the current school operations model cannot be improved by the recommendations offered by the National Commission. The fourth purpose is to suggest that some form of technological intervention must be made before any substantial increases are made in productivity

Are Quality and Productivity Problems?

Numerous researchers have recently addressed this persistent question from a variety of perspectives: including Murname (1975), Heyns (1978), National Commission on Excellence in Education (1983), Coleman, Hoffer, and Kilgore (1982), Aker, Spaulding, Adams, and White, (1984), Walberg (1984), Kozol (1985), Bickel (1986), Pallos (1986), Bureau of the Census (1987), and Walberg and Fowler (1987). Common among these researchers and reports is the conclusion that school performance and quality are severely inadequate to meet the needs of modern society. Further, Boulding (1972), established that not only are the results disappointing, but that the real costs of schooling doubled between 1930 and 1970.

Parent organizations, state education agencies, the United States Department of Education, and blue ribbon national commissions, have all agonized about the problem, and some have offered concrete proposals for improvement (e.g., National Commission on Excellence in Education, 1983). Virtually all of these proposals have centered on trying to repair, stimulate, and improve the existing educational establishment. They have implicitly accepted the current operations model as adequate and have urged changes intended to improve it. A major contention in this paper is that the existing operations model is seriously flawed and cannot simply be patched up for modern use. A second contention is that even if these proposed changes could be successfully made, they could produce, at best, a limited improvement.

Commissions, state education agencies, and teachers organizations, all seem to urge additional funding, but the empirical evidence has not demonstrated any solid relationship between funding and school performance (Boulding, 1972; Murname, 1975; Walberg & Fowler, 1987).

Is there a documented problem in quality and productivity? In this paper, "quality" refers to both quality control and quality assurance concepts as elaborated by Lessinger (1976). The quality control question centers on how closely what happened resembled what was planned, (e.g., Do actual mean achievement scores match expected scores?). The quality assurance issue addresses the fitness for the intended use, (How well prepared is the graduate to meet employability requirements or succeed in additional schooling?) (Juran, 1974). Productivity refers to the relative achievements of the students compared to the relative expenditures.

Walberg (1984) compared American students with those in other developed countries and found that we are clearly second-best compared to any other industrialized country on commonly used measures of language, mathematics, and science. More recently Walberg and Fowler (1987) concluded:

> A substantial literature shows no consistent association between spending on education—including total per-student expenditures as well as specific spending on such things as class-size reductions, physical facilities, teacher salaries, and the like—and how much students learn. (p. 6)

Aker, Spaulding, Adams, and White (1984) used an absolute output measure, functional literacy, to infer instructional outcomes. They estimated the number of functional illiterates to be about 12.5 million, with the number not able to function at levels of conceptual development attainable by some students in good high schools to be more than 50 million (see also Kozol, 1985). According to the United States Center for Education Statistics, the average score on the international eighth grade math test was 52; the mean for American students was 46. The functioning and literate remainder of the society is carrying this economic burden.

According to a recent story in the *New York Times* (1987), a hiring program established by four New York Banks to employ 250 qualified graduates, yielded only 100 graduates who could pass the entrance test that was roughly equivalent to an eighth-grade mathematics test. The United States Army must spend millions of dollars each year to prepare high school graduates in functional basic skills prerequisite to job training programs (Branson & Farr, 1985).

If the banks cannot find qualified applicants in times of high youth unemployment, and if the taxpayer must pay twice for the same schooling as it does when Army recruits must be given remedial instruction in basic academic skills, we will certainly continue to find ourselves in situations of low industrial productivity and a worsening trade deficit. Thus, Walberg (1984) argued coherently that our schools have not kept up with even the smokestack industries in terms of increased productivity when measured over comparable time periods.

While we must make our individual, personal evaluation of school performance, there is an emerging consensus that the current levels of performance and efficiency are unacceptable, and that direct action is required soon. But what kind of direct action? There appear to be two distinct views:

- Those who believe that significant improvements can be made in the present operating concepts and models (National Commission on Excellence in Education, 1983; Finn & Tomlinson, 1987; Florida Department of Education, 1987), and;
- Those who accept the argument, to be urged here, that *fundamental* redesign must occur before any important improvements can be made at all (Branson & Grow, 1987; Reigeluth, 1987, in press).

Common among these researchers and reports is the conclusion that school performance and quality are severely inadequate to meet the needs of modern society.

Responsibility

In the operation of any organization in which professionals come into contact with clients, the professionals must assume the responsibility for the success or failure of treating the client. Individual diagnosis, therapy, and programs of implementation must be carried out diligently to make a difference in the lives of the people served. To the schools, this would mean taking the best available practices and the best available research data and putting them together to optimize a treatment system that would produce results. Successes and failures would have to be identified and attributed.

Although I have tried to set the stage for urging improvements, I want to declare explicitly that I do not believe that there is any culpability in the current state of affairs. If there is blame, we are all to share it. We do have a significant problem and we must get on to fix it, but to fault any group would be entirely wrong.

The Life-cycle of a Maturing System

Life cycles of maturing technologies and systems can be represented by a sigmoid curve as presented in Figure 1. The introduction of any process is characterized by an extremely slow start with a limited relative productivity. This slow beginning gives way to a rapidly changing rate until increases in productivity begin to taper off and the system approaches the upper limit (asymptote) for the process or technology. For any system or enterprise, there is an upper limit of achievement at 100%, which is never reached. As indicated in the curve, the view presented here is that the traditional education model has attained about 97% of its possible performance.

By going through this process of estimating the total potential improvement in outcome or productivity, a process which I call "back-end analysis," it is possible to estimate the contribution of any proposed fix or change in the system. It is the same general process that we go through when we decide to repair or replace any major piece of equipment or system. Costs are traded off against value or productivity, thus providing the rational basis for a decision.

Technology Perspective

Compare the existing concept of school structure and operations to the design and operation of aircraft. The history of aircraft design roughly parallels the history of educational research. About the time of World War II, 1940, aircraft design for single and multi-engine aircraft had been effectively optimized. That is, engine manufacturers and airframe manufacturers had produced about as much efficiency as they could produce under the existing piston engine technology. For each aircraft mission, the designs were approaching the practical upper limit of capability.

Aircraft designers must take into account three major factors when producing an aircraft for any defined mission. These factors are:

- Speed,
- Payload, and,
- Range.

For any mission, these three variables must be traded off—optimized—to achieve the performance requirements. It is not possible to maximize all three variables simultaneously. If you want more speed, you must give up range or payload. Mission requirements for aircraft design are the equivalents of system requirements for what could become an educational "system." While education may now be a system in the sociological sense, it is not, in my view, a system in the cybernetic sense. The mission and system requirements for education will be discussed in a later section of this paper.

I will argue here that all major possible improvements to schools, under the current management model, had been implemented by 1950 or 1960 at the latest. The results under this model have reached their practical upper limit; that is, performing in the vicinity of 97% to 98% as well as they can ever function *according to the current design philosophy*. Trying to make improvements to operations under the current management structure can yield, at best, only a 2% to 3% improvement and to achieve even that trivial gain would require immense investment. It is well known in quality programs that the last 2% to 3% improvement to a "zero-defect" goal can cost half again as much as the first 97% (Lundvall & Juran, 1974).

Marketing Perspective

Such curves can also describe the market introduction-penetration-saturation process for products and serv-

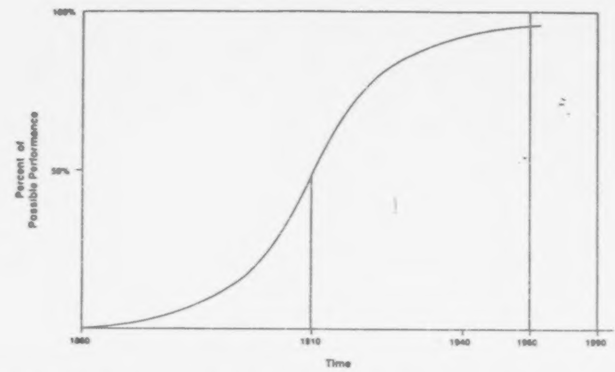

Figure 1. Hypothetical upper limit of productivity of the traditional school operations model as a function of time. This function was adapted from the concepts of maturing technologies and markets.

ices as well. The curve describes the early process or penetration in terms of the absolute percentage of possible achievement. From a marketing perspective, if 50% of the American people now see a dentist regularly, as indicated on the curve, there is a theoretical maximum possibility that dentists could see a 100% improvement in their market. In this particular case, the 50% they now see probably represent 90% of the currently available purchasing power. While they could see 100% more people than they now do, most of those people not now being seen cannot afford to pay, thus, there is not a high probability of a 100% improvement.

Negative Research Results

It is one of my major contentions that many of the negative findings with regard to discovering what many people believe are intuitively obvious relationships among educational practices (teacher pay; per pupil expenditures; teacher training; class size) are due to the near asymptotic condition of existing practices. When all schools have approached the practical upper limit of performance, there is so little room for improvement in the traditional variables of interest, that significant differences reported in the literature are more parsimoniously explained by sampling error. That is, the true difference in population means is zero; those differences that are found are due to chance (see Bickel, 1986). I will further contend that this account is far more parsimonious than the endless explanations of the practitioners (see Boulding, 1972) who believe that the true mean difference is not equal to zero.

Yes, some schools are better than others, some cost more, some have better students, some have better teachers, some have better principals, but these distributions are normal and *independent*. Relationships among them are better explained by sampling error than by methodological faults in the research. Traditional school attributes and operations variables are random processes, not principled ones. Making one school better can often make other schools worse. A given school gets better, but the average for all schools does not.

Suppose, though, that this argument is completely wrong; that true differences do exist. The reported effect sizes are still trivial. That conclusion is also best interpreted from the perspective that there is no important room for improvement (see Glass, 1987).

Conventional Fixes

With the noblest of motives and the best interests of the nation at heart, the National Commission on Excellence in Education (1983), made numerous recommendations that are not likely to have any real and immediate impact. We are a nation at risk. In this paper, I will argue that their proposed solutions to school problems cannot be effected and implemented, and, even if implemented would not result in significant improvements. Improvements that could have an impact, such as those described by Walberg (1984), cannot be widely implemented, and even if implemented could not now be sustained and managed (see Reigeluth, 1987; Parish, Underwood, & Eubanks, 1986-87).

I will further contend that blame-placing and single variable fixes, such as teacher training, pay incentives, longer school days, and longer school years, cannot be efficient means of improvement. The problem is principally one of system design, not of faulty operation. It is critical to make that distinction. No group can be singled out for blame: not teachers, not principals, not school boards, not parents (see Finn & Tomlinson, 1987; Glass, 1987).

To blame these groups for functioning in the system as their roles have demanded, would be similar to blaming the pre-antibiotic medical establishment for failing to cure infections. Better physician training, better nursing training, and improved hospital management would have helped little without the technological breakthrough of penicillin.

There is also a continuing and well-lobbied view that schools do not have adequate financing, in spite of consistent findings that school quality is not related to school cost (Boulding, 1972; Murname, 1975; Walberg & Fowler, 1987). Those results can also be readily explained from the near-asymptotic performance perspective. Since the greatest percentage of additional funds provided to the schools are consumed by teacher salary increases, no affordable level of funding would ever be thought of as adequate. Thus, the problem is one of resource use, not of resource amount.

Systems can fail because they are obsolete; because they are overloaded; because they have fundamental design flaws; and, because they have inadequate management.

Design Versus Operations Problems

The principal argument here is that fundamental flaws in management and operations permeate the contemporary education establishment. The education sector was never *designed* to meet today's needs; it matured by reaction to various political and social influences over an extended time period. That maturity is represented by the sigmoid curve in Figure 1.

Systems can fail because they are obsolete (which I believe is the case in education); because they are overloaded; because they have fundamental design flaws; and, because they have inadequate management. Some examples of system failures with different causes might clarify this point.

Overload. In the mid-1960s, there was a complete electric power blackout in the Northeast, resulting from a surge in demand and a design problem in the distribution system. It was not possible to identify a group or person responsible, only a failed part.

Undercapacity. Current analyses of the United States air-traffic control system indicate that it cannot meet the demands placed on it, causing an increase in flight delays, near misses, and other unfavorable statistics. The problem cannot be blamed on the air-traffic controllers, or President Reagan for firing members of the striking union, or the airlines. The system cannot meet public demand. Reducing the number of flights is a palliative, not a cure.

Obsolescence. Galley slaves were once used to power ships. Could the navy have really improved the performance of the armada if they had: selected stronger slaves; trained them better; given them more money, fewer lashes, or better rations; waxed the hull; redesigned the oars; provided swivel seats; or, told them how important it was to the Queen for them to work harder?

NASA's Management System Failure

In early 1986, on the morning of President Reagan's State of the Union message, the space shuttle, Challenger, was launched from Cape Canaveral during a rare Florida cold snap. Shortly after liftoff, one of the main booster rockets exploded and caused the shuttle to fall into the Atlantic. Instantly, a national demand was issued to find the culprits and deal harshly with them. Ultimately, it was found that the proximate cause of the accident was a defective o-ring.

If you believe that disaster was an accident caused by a defective o-ring, then you will probably also believe that single variable improvement schemes will improve public education. The accident was caused by a major *system flaw*. The shuttle was launched on a day that was clearly too cold for the vehicle to endure. The NASA launch director was warned by the manufacturer that the weather was out of tolerance. The contractor was threatened with reprisals if he persisted in recommending a launch delay.

If there is a major system flaw, any new launch could go with some other system out of tolerance—temperature, cloud cover, lightning, wind, and many others. Fixing the o-ring, though probably necessary, is not sufficient to fix the system. The o-ring was merely a scapegoat. NASA is, however, still throwing money at the o-ring, and it is attempting to change its system. Will it succeed in solving both problems? A large government system is a close analogy to the kinds of problems being discussed here.

In each of these examples of system inadequacy, the owners and operators were not at fault, the system design and the available technologies were not adequate to meet the increased needs. While no systems are perfect, examples of effective systems, presented in the sections that follow, should help to define the scope of the problem addressed here.

Meeting Changing Requirements

In the 1950s, a major bank projected the number of checks that would be written by customers during the next ten years. Then, by estimating the number of checks each clerk could process in a day, they came up with a staggering conclusion: There would not be enough space in the bank for the number of people required to process the checks they forecasted to be written. What to do? Redesign the check processing system by including optical character recognition and automatic data processing. Without the availability of a new technological development, the banking system, as we knew it, would have collapsed from the paperwork burden.

In my hometown, Shawnee, OK, making a telephone call involved lifting the handset, waiting for the operator to say, "Number, please," then giving her my friend Tommy's number, and hearing her ring the number or say, "The line is busy." When my neighbor, Louise, was the operator, she would even say, "There is no one at home, I just tried that number." There was no need to complete the call.

Recently, I pressed one button on my automatic dialer and was speaking to a colleague in Paris in less time than it took Louise to ring Tommy. In the last twelve months, my telephone has not been out of service for a single day. The voice quality is good, it transmits data, it is an excellent value for the price, and, by adding features like international direct dialing, the system has continued to meet my increasing needs by adding features. Though mature, the system is not obsolete. Wires were replaced by microwaves, microwaves by satellites, and both have been augmented by fiber optics. All permit me to use the same black dial telephone that I have had since 1960.

The essential elements of success in both cases has been to focus on system output requirements, to keep what was good and what worked in the old systems (handwritten checks; black rotary telephones), to replace that which no longer met system output requirements (local service operators), and to increase the capability of the systems through ingenious applications of technology and effective management.

How could major change be managed in these two well entrenched bureaucratic systems, to meet changing needs? What can be learned from organizational changes that have worked, that could be tried in the educational establishment? Is there an available technology that could improve education? Since we have convincing research evidence that there is (Walberg, 1984), why have similar technologically-based changes not taken place in education?

Recommendations of the National Commission on Excellence in Education.

To illustrate the difficulties of making improvements within the confines of the current establishment, let us examine selected recommendations from *A Nation at Risk* (1986), in light of what has been learned in educational research and development during the last 75 years.

Recommendation A

"Minimum requirements of 4 years of English, 3 years of mathematics, 3 years of science, 3 years of social studies, one-half year of computer science," (p. 24 ff).

Three problems are: first, numerous studies of mastery learning have taught us clearly that when students are managed to achieve mastery of the objectives, different amounts of time are required for different students. Stating recommendations in terms of years of instruction rather than intellectual competencies, is an erroneous practice no matter how widespread.

I want to declare explicitly that I do not believe there is any culpability in the current state of affairs. If there is blame, we are all to share it.

Second, all emphasis is on *teaching* rather than providing learning. On saying, "Number please," rather than arranging fast, efficient connections.

Third, the report recommended that more hours be spent in school each day for more months, rather than providing for increasing time-on-task and providing effective feedback.

Recommendation B

Raise standards and expectations for improved academic performance, (p. 27 ff).

A commendable goal. One just *cannot* urge lower standards.

One problem is: It is the same as urging better times for the track team with no mention of how to reach that goal. Just as in manufacturing, quality cannot be inspected into a product, it must be built there (Juran, Gryna, & Bingham, 1974). Higher standards cannot be tested into an educational system, competencies must be systematically built into the students.

Recommendation C

Have higher standards for teachers and raise teacher salaries, (p. 30 ff).

Two problems are first, having higher standards (higher grades in college) for teachers does not address the issues of competencies they ought to have and know how to teach well. Following the medical example, in the absence of penicillin, flunking out more physicians would have had no impact on the infection death rate.

Second, paying higher salaries to teachers has only political appeal. There are no known instances in which paying incumbent teachers more money resulted in higher quality or productivity. Further, the same class can be taught equally effectively and much less expensively, by teachers with three years of experience instead of twenty years of experience. There is no evidence that paying higher salaries to those teachers for another 20 years will result in increased effectiveness or productivity, although it would certainly result in increased costs (see Murname, 1975). A salary structure that provides increased pay for more time in service and more hours of instruction at the university may not be the best option for the taxpayers (see Boulding, 1972; Walberg & Fowler, 1987).

Florida's recent experience indicates that only about 7.75% of the workforce of some 100,000 teachers are new hires

There are no known instances in which paying incumbent teachers more money resulted in higher quality or productivity.

in any year. If one assumes that these new hires are distributed approximately randomly across the grades and the schools, it would amount to about 4 new teachers per school per year. At those odds, each new hire would have to be a miracle worker to have any real impact on the establishment. Unfortunately, unless the new hire is the CEO (see Iacocca, 1984), the literature tells us clearly that the organization is far more likely to shape up the new hire, than the new hire is to shape up the organization (Cornbleth, 1986).

Do More, More

Another government publication, *What Works*, (United States Department of Education, 1986; see also Glass, 1987; Finn & Tomlinson, 1987), urges schools to adopt practices known to work in other schools. Increasing quantity and quality of homework are urged as a means to "... teach students to be independent learners." This benefit is presumed to be a byproduct of their learning the subject matter. Homework is treated as an end rather than a means. It is reasonable to raise the design question, "What is the instructional, management, or discipline problem for which homework is the optimum solution?" Do students from all socioeconomic groups have an equal chance of profiting from homework? Should they?

The Miracle Worker

In another section, schools are urged to get the "right" principal because good principals can turn bad schools into good ones. A management structure that leaves the decision about whether a bad school ought to be turned into a good one, to the whim or inability of an incumbent principal, is going to fail no matter what it attempts to do. The very fact that a bad school is known to exist in a system ought to scream loudly enough to cause direct management action to insure that the school is as good as it can be.

Regardless of management's indifference or ineffectiveness in making schools as good as they can be, blaming a principal for bad school performance is much like blaming a 1940 hospital administrator for deaths caused by infection. The existence of bad schools is clear evidence of system failure, not of bad principals.

Probably the most dangerous aspect of the report, suggesting that the solution lies in getting the right principal, is the fact that we will be looking for miracles in the person, not in the system. There just aren't that many miracle workers available. The true hazard stems from the publicity about an occasional miracle—someone actually does come in and save a school from disaster—then the superstition builds that miracle results can be similarly obtained in other schools. When dramatic results are not achieved, the principal gets blamed, or changed, nothing is done to improve the system, and as in any other superstition, the endless cycle of false hope is sustained. A specific example of how a principal can work negative miracles will be presented later.

No matter how well motivated the reports may have been and no matter how prestigious the members of the Department or Commission, I believe that these reports and others that preceded them have suggested that we do more, and longer, of what is not working now, pay more for it, make it more difficult for new applicants to get hired, and screen more students out of the universities. These reports have not, in my view, provided us any basis to hope for success in the 1990's (but see Smith, 1986).

Historical Perspective

In the late 1960's, the United States Office of Education undertook an extensive study of the operations and performance of the public schools in the United States (see Morgan & Bushnell, 1967; Morgan, 1969). When they studied, observed, and interviewed groups representing teachers, administrators, principals, school board members, and the general public, they concluded that the schools were as they were and were unlikely to change. Their most significant observation was that *there were no villains in the piece*; the blame for the massive problem could not be laid at the feet of teachers, or unions, or parents, or elected school board members, or principals, or any other power group. The performance problems in the schools were caused by inherent structural and operations faults and the probability of success of any single "fix" to the existing model was low.

Morgan and his associates recognized that system faults must be addressed with system solutions. Simplistic, single-variable fixes, advocated by different power groups, were found to be completely inadequate. Subsequently, they organized a consortium of school districts across the country to participate in the development of an organic curriculum (Morgan & Bushnell, 1967; Morgan, 1969). They sought to develop a systemic curriculum that would relate broad new ideas, new concepts, new thoughts, and vastly improved methodologies to get the schools closer in touch with the society they serve. In spite of the hard work, money, time, effort, and good intentions, the consortium could not make and sustain any important changes.

Why didn't the new approach survive and flourish? There were three reasons. First, there was not an adequate infrastructure to provide people with the knowledge and skill they needed to operate in the new environment. Second, all of the work was being carried out in the face of tradition; compromises had to be made that reduced the impact of the changes. Third, over time, goal conflicts developed or were found within the cooperating systems and within other programs in the Office of Education (Branson, 1979). As a consequence, the money programmed for the change was not provided over a sufficient period of time to institutionalize the new model.

After hearing about Morgan's experience, and clearly understanding the basis for his conclusions, I wanted to try my own hand at making school fixes. Because I had always worked on Instructional Systems Design programs from the top down (e.g. Oakland Community College; Parks Job Corps Center; The United States Naval Academy) and was thoroughly familiar with the pockets of resistance that had to be overcome in those programs, I naively assumed that if ideas and proposals for change originated at the grass roots level, they would be accepted, implemented, and then institutionalized. Based on my own experience and the change agent literature, I believed that whatever teachers liked, teachers would do, and that they would do only what they liked.

Flat management models do not permit the development of high-performance systems regardless of whether one is working in schools, factories, government agencies, or athletic teams.

In early 1970, I was trying to find a school in which to begin a cooperatively developed instruction and management model, keep that model in place for a period of time, manage the program well, and make planned adjustments to the design and operation as required by using the accumulated performance data. I looked at candidate schools in the Bureau of Indian Affairs, continuation schools, proprietary schools, and others, including military training programs, finally selecting a school operated by the United States Dependent Schools—European Area (USDESEA).

The USDESEA Project

In 1970, the Center for Educational Technology at The Florida State University signed a contract with USDESEA to provide design and development service to the Karlsruhe American Elementary School in Karlsruhe, West Germany. Overseas Department of Defense schools are identical to typical schools within the country, except they have a higher turnover of students. As military personnel are transferred from one post to another, their children get hopelessly out of step with the other students who are not moved. It was the turnover problem that provided a focus for the systematic curriculum design.

During a period of three years, we worked with teachers and administrators to define an educational mission consistent with Army needs, elaborated program objectives, and developed a plan of action with milestones. In-service training was provided for teachers and administrators to establish the basis of cooperation in designing a new curriculum, developing it, and implementing it.

This finally approved curriculum was a hybrid of off-the-shelf materials developed by the Regional Educational Laboratory for the Carolinas and Virginia (RELCV), materials developed by teachers specifically for the school, and other commercial off-the-shelf courseware, traditional and nontraditional.

The RELCV-developed program was the *Individualized Mathematics System*, a fully integrated, continuous progress K-12 mathematics curriculum, that had been carefully field tested in schools throughout the Southeast. In addition to mathematics, the language arts, science, and social studies parts of the curriculum were also developed on a vertically integrated basis.

From all professional viewpoints, it was technically sound, it worked, and it was a perfectly acceptable curriculum to the Karlsruhe faculty. The project staff and teachers believed that we had made a major breakthrough in technology transfer; we had installed a research-based and fully tested curriculum in a school that had not been one of the tryout schools.

The first tryout of the new curriculum and materials was during the school year 1972-1973. Based on that tryout, certain revisions were made to accommodate problems that had developed. There was still, however, solid support from the teachers and principal. During the summer following, the final versions of the materials were reproduced and plans were made to implement the program the following year on a school-wide basis.

Comes the Villain

A new teacher, who was transferred to the school in the fall of the 1973-74 school year, decided not to participate in the integrated curriculum. That fourth grade teacher told the principal to remove her class from the program; she intended to use the books she had used the previous year. The project staff and other teachers protested this arbitrary decision to the principal and to the various central office coordinators, but to no avail.

The principal, under some strange interpretation of the concept of academic freedom, was unwilling to tell the teacher that this was a well developed program for all students in the school and insist that she participate. The principal, not one of the miracle workers described in *What Works*, and who had been appointed during the second year of the project, permitted that single teacher to abort a program that we had spent three years developing. He really didn't want more work for himself or the administrative heat that would have been generated by insisting that the teacher participate.

This decision illustrates precisely why the management structure is faulty. In fairness to the principal, he did not participate in the plans that would affect his professional life. The school culture of the day did not require that he accept what had been

The view presented here is that the traditional education model has attained 97% of its possible performance.

done by his predecessor. He could regard what went before his arrival as invalid, unimportant, trivial, or excellent, according to his own whim. The fact that the central office had invested many thousands of dollars and thousands of person-hours to develop the curriculum was of no consequence in his decision (Branson, 1979).

While we tried all avenues known to us, we could do nothing to set the project right. We finally learned that so long as individual teachers can make whimsical decisions to abort major programs, it will be impossible to make improvements in education. Teachers are unable to make system fixes.

While we recognized that this particular problem would not have happened in many well-managed schools, particularly when we had the support of the principal and the entire staff, it does reflect the critical importance of the principal to any change effort. More importantly, it highlights that fundamental flaw in school management. While thousands of dollars were spent in developing a new approach, the management structure was not sufficient to get it implemented and sustained. The same kinds of failures have occurred repeatedly in numerous single school and district programs throughout the country (see Parish, Underwood, & Eubanks, 1986-87).

The Korean Model

Morgan saw the potential to cause educational change from another perspective. He reasoned that if one could really get central government support, and the support of significant academics and ministry staff, change models could be implemented. Instead of starting at the grassroots where I was working, he started with a major needs analysis and master plan in Korea (Morgan & Chadwick, 1971). In Korea, the federal government is paramount. With money from the United States Agency for International Development, and extensive support from the Korean government, he initiated and brought to fruition a fundamental improvement in Korean education (Morgan, 1979).

Why did Morgan's ES '70 program (1969) fail and his Korean program succeed? Both had funding from the United States Government, both were managed by the same person. Both had the involvement and support of significant members of the educational community. Both were managed from the perspective of the central government.

First, there was a clearly documented problem; the Korean schools could not meet the needs of the society. But that conclusion has been repeatedly reached in the United States. Second, there was a strong central government commitment to make the necessary changes. That is not the case in the United States (see Finn & Tomlinson, 1987). Third, the Koreans created a technological infrastructure, in the form of the Korean Educational Development Institute (Morgan, 1979), to provide design, training, research, and evaluation services to the country during the time of transition. That kind of institute does not exist in the United States. Finally, the combination of the overall commitments and the developed infrastructure kept the program in place long enough for it to be adopted, to be successful, and to be institutionalized on a national basis. That last point is critical. In the United States, the central government funds projects annually, and rarely supports projects for longer than three years. Three years is not long enough to make a fundamental change in any large system.

Management Structure

The organizational model of the typical American school is extremely flat. That is, one principal is assigned to supervise as many as thirty or more teachers and other staff. Adequate supervision of that many teachers by one principal is logically and empirically impossible. Flat management models do not permit the development of high-performance systems regardless of whether one is working in schools, factories, government agencies, or athletic teams. The span of supervisory control has been documented since at least the time of the Roman Empire, and probably before the Pharaohs, to be seven plus or minus two.

In Rome, where teachers were first put on the public payroll, the school model was based on one administrator-teacher and several teachers, but not thirty. Schools operated with selected students and were small enough to be easily managed by one person. That model met the needs of the Romans of the day, though it certainly does not meet their current needs any more than it does ours. Recent research suggests that there is a negative relationship between school district size and achievement (Walberg & Fowler, 1987). However, if one accepts the practical upper limit hypothesis advanced earlier, this modest relationship would likely be attributed to sampling error.

When schools in the United States were started, they, too, were small and could be comfortably managed by one principal teacher. Then, the colossal error occurred. It was assumed that one principal could manage 9 teachers, then 15 then 30, but no true management analysis was made. In those days, there was no longitudinal evaluation of the schools. They existed as they had mutated and evolved from the Roman model. They were never planned according to a set of defined requirements; they were rationalized according to what they were. The current management and operation structure of the schools has evolved from an original model that served small primitive schools adequately. The same approach is now used in an attempt to manage large schools and districts. Generalizing management structures that are perfectly suitable for small schools, with simple requirements, to much larger schools, trying to serve a complex society, leads inevitably to chaos. It has.

There have been no sustained managed changes in the typical school model in the last one-hundred and fifty years even though there have been enormous advances in educational research and development that could provide the basis for changes in instruction, organization, and management. There is a fundamental difference between designing a management structure to achieve a mission and a current school administration which results from evolution, reacting to fashions, trends, and political whims. The public school administrative structure was never designed to serve mission oriented requirements.

To their well deserved credit, hard working and dedicated administrators and teachers had optimized existing management and operations models by 1940. Certainly by 1960, traditionally organized schools were operating as well as they would ever be (see Figure 1). While minor improvements may be made by fine tuning the traditional model and procedures (e.g., by implementing the recommendations in *A Nation at Risk*), the chances of any significant improvements are effectively nil; the operations asymptote has long ago been closely approached. It is still my conclusion that more than 95% of all possible improvements in the system under its current management and operations configurations have already been made. Unfortunately, national commissions are willing to accept the obsolete; they are willing to commit resources to obtain that last 4 or 5%.

System Requirements

What are the major flight variables (e.g., speed, payload, range) in education? For the purpose of the argument here, an abridged list might include:

- To provide for effective and efficient learning throughout the range of student talent served by the district.
- To provide for socialization, growth, and development.
- To provide a safe, nurturing environment that promotes physical development and recreation.

Instruction

These requirements must be traded-off against resources and time to achieve the mission. Within each variable, there are numerous well established methodologies that define the state-of-the-art. For example, what can be done to make learning more effective and efficient? Walberg (1984) has documented the utility of reinforcement, mastery-learning, reading-training, cues and feedback, among many others. Others have established time-on-task as critical. Keep in mind that Walberg's findings refer to traditional classroom organization and that the interventions that he described were not designed into an operating system, they came from reports of research projects in the literature.

Socialization

What can be done to enhance socialization? Again, Walberg (1984) urges some important practices: Cooperative learning, and class morale. Delquadri, Greenwood, Whorton, Carta, and Hall (1986), among many others, have urged classwide peer tutoring. There are numerous approaches to improve socialization, such as manipulating teacher expectations (see Thorndike, 1968).

The existence of bad schools is clear evidence of system failure, not of bad principals.

Custody

How can the custodial function be facilitated and improved? Madsden, Becker, & Thomas (1972), present a model for student management that has a very impressive history in improving discipline and performance. There are many other research-based procedures available.

These three requirements can be manipulated and traded-off to carry out the mission successfully. Success will not just occur spontaneously to meet the mission or system requirements. The entire process must be managed into place and competently operated to achieve the planned results. Operations refers to the day-by-day diligent attention that is devoted to the progress of each student, the early identification of any discrepancy between expected performance and actual performance, and the action taken to correct these discrepancies. Yes, adequate data management systems do exist that are fully capable of keeping up with thousands of students.

Back to the Drawing Board

How did aircraft designers improve the performance of piston-engine aircraft beyond their theoretical upper limit? They didn't. A totally-new power concept was introduced in the 1940's, the jet engine; a fundamental advancement in technology. When the jet engine was brought into the aircraft industry all three major flight variables—speed, payload, and range—could then be completely reset and reconsidered. Now it is possible to design aircraft that will fly faster, farther, and carry greater payloads than were possible with piston engines, even though the same three mission requirements must still be traded off. Most important, the designers were aware of the technological advance and knew what to do with it when it was made available. They were seeking ways to make improved technological changes.

Is there a jet engine of education? Perhaps it has not been invented yet, perhaps it has arrived. Regardless of the form it takes, I believe that it will be a large advancement in information processing technology. Some argue that it is CD-ROM, others that it is interactive videodisc. The form of the hardware is not important. What it must do is to bring vast amounts of information into contact with the appropriate sensory modality and manage the input and output of that information to produce effective learning and affective experiences (see Ofiesh, 1987a, 1987b).

We must find a way to bring the available research and technology in the behavioral, management, and communications sciences to bear on the school problem. Unless we can find a means of achieving significant change in public education—the jet engine of instruction and the improved airframe structure of management—it will not be possible to make any real improvements in the ability of the educational establishment to meet the ever-changing mission requirements, and education will not be able to support national priorities.

What Will Not Work

Continued performance of old school operations rituals will be no more effective than practicing medicine exactly like it was practiced in 1940. Trying to prop up the status quo with single variable fixes cannot increase productivity beyond the practical upper limit of the traditional school model. Fixing one school by changing principals does not improve the overall performance of a district.

The Implementation Problem

Regardless of how many new research-based programs for improvement of public education are discovered and offered, they are regularly rejected at local levels. Sometimes they are rejected because of disagreement; sometimes because of ignorance. From the standpoint of trying to make improvements, neither excuse is forgivable. If the same practices were followed in medicine, or engineering, or other major professions, there would likely be a landslide of lawsuits charging malpractice (Stewart, 1971). Failure to take prudent action is just as professionally irresponsible as taking incorrect action.

Implicit Models

When considering how one must make changes in public education, keep in mind that all of the people who manage the schools and districts, in which new programs could be implemented, have a strongly traditional concept of school operations, teaching, and administration. I call these traditional concepts an *implicit model*. It is implicit because one learns the proper traditional models, roles, and attitudes throughout academic life, incidental to learning the subject matter. As each of us experiences elementary school, middle school, high school, and post secondary education, we develop an internal reaction to them. These reactions are both intellectual and affective. The personal concept of the good and bad features of our personal schooling are true for us, but these impressions are not the correct data-source for developing valid knowledge. It is most likely that our personal experience base is not as accurate as the more objective empirical base, but, we tend to trust our own intuition, nevertheless (see Lerner 1985 for an elaboration of how these early experiences dominate our thoughts and behaviors).

We must find a way to bring the available research and technology in the behavioral, management, and communications sciences to bear on the school problem.

Explicit Models

Change models (Burkman, 1987), instructional systems development (Branson & Grow, 1987), and other approaches for improving instruction (Gagne & Briggs, 1974), improved management approaches, such as differentiated staffing (English & Sharpes, 1972), and well managed peer tutoring are all *explicit* models, because they clearly indicate both the form and the content of the intervention in the specifications.

Teachers and administrators do not know in advance, or solely from past experience, what is to be called for in the new approach. Training is required. How many times have you heard, "Why, there is nothing new about the systems approach—good teachers have been doing that all along." And, from Statistics 101, you also know that half of the teachers are below average; at least half of them have not been following reliable, empirically developed practices on their own, nor have they been *managed* to do so.

Systematically designed models and applications of research-based solutions always require approaches to instruction that differ from the traditional school model. That is not at all strange. We do not expect people to have known research outcomes prior to the time that the research was done. School administrators are not likely to have experienced any systematically designed courses or curricula. Most of them will have gone through traditional schooling in elementary, middle, high school, and college and they will consider any variation in the implicit model of instruction or management system to be abnormal, improper, and perhaps unnatural. Without effective management, they will not be able to imagine systematic design and operations as an important method of improvement.

If one accepts the practical upper limit hypothesis, probably the most seductive and most seriously erroneous idea that surfaces from time to time, is that somehow educational system improvements can be made by improving preservice teacher training and increasing the salaries of the incumbents. Why blame the teachers? The amount of variance that could be accounted for on the basis of improved teacher-training for the current operations model is probably of the same percentage magnitude as can be obtained by the piston engine aircraft operator who waxes the wings. Wing-wax and teacher-training do not account for a large percentage improvement. Teacher-training is a typical and naive single variable solution.

If there is no management structure in place to insure that effective and proper treatments are applied to all students consistently, it really makes little difference what preservice training is given to teachers. When individual teachers and principals can decide whether they offer good quality instruction, no one can be sure of getting it.

Fundamental to the notion of the implicit model of instruction is the concept of the "classroom." In my view, the fact that the classroom model (one teacher, one class, one room) still operates when we have solid empirical evidence about school learning and other variables known to impact student performance, including basic classroom management techniques, is a preservation of the past and clear evidence that the system must be changed. The classroom concept is archaic and should be abandoned in favor of a school environment that has been designed to serve specific purposes set forth in the system requirements. The design should provide for individual learning, space for group processes, and should be organized according to its function, not vice versa.

Some people believe that Jefferson's insistence on decentralized control of education is responsible for the survival of the Republic. Others believe that it is a terribly high price to pay for freedom. The problem for which decentralized education was the solution has been over for one-hundred years, the real threat in this century has been from abroad. Unfortunately, the price is getting so high that we can no longer afford it.

Conclusions

1. Based on the available evidence reported in the literature, both popular and professional, there is indeed a discrepancy between the expressed needs of the society and the productivity of the schools. There is a critical requirement for substantial improvements in performance.

2. The research literature has provided numerous tools and approaches to improve existing practice in instruction, socialization, and custodial functions which are all critical to school operations.

3. The organizational and management structure is based on a model that has been obsolete for many years and which is totally inadequate to operate and control the large and complex required programs necessary for improvement.

4. The existing management, operations, and instructional models have completely matured. Their productivity function is near the attainable upper limit; little further improvement can be made without fundamental redesign.

5. All other major operating sectors in the society have had to incorporate technology to meet the increasing demands for service and products. Many of these sectors have gone through several generations of technology to meet the nation's needs (manufacturing, communications, services), while the schools persist in adhering to an archaic model.

6. Recommendations provided by national commissions and conventional fixes proposed by members of the establishment have uniformly urged putting more effort into the status quo. Suggestions such as increasing standards for teachers and students, paying incumbents more money, increasing per pupil expenditures, and lengthening school days and years, will add to costs but cannot add substantially to benefits.

7. It is essential that the entire establishment go through a fundamental redesign to define mission and system requirements, then develop empirically based methodologies to meet those requirements.

8. As long as there is no externally imposed requirement for change, school administrations will not change. There is now no known way to cause the necessary and sufficient changes that would make a significant difference.

Author Note. Thanks are gratefully extended to Mr. Richard W. Foster of the Astronautics Technology Center, Madison, WI, whose critique and valuable suggestions made significant improvements in this article.

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Mr. VALENTINE. Thank you very much, Mr. Allison.
Ms. Stanion?

STATEMENT OF THERESA STANION, DIRECTOR OF GOVERNMENT RELATIONS, INTERNATIONAL COMMUNICATIONS INDUSTRIES ASSOCIATION, FAIRFAX, VA

Ms. STANION. Mr. Chairman and members of the subcommittee, thank you very much for inviting me here today to comment on the subcommittee's draft science education bill. I am the Director of Government Relations for the International Communications Industries Association, ICIA. We represent audio, audio-visual, video and computer dealers; commissioned agents; manufacturers; software publishers and producers; independent media producers; film, video and software distributors; and education and trade publications.

Our members include large corporations as well as small businesses that contribute substantially to local economies and play an important role in producing innovative technologies. Some of our members specialize in the educational market, while others serve a broader market, including the corporate, industrial and government.

I would like to emphasize the following points. ICIA, the International Communications Industries Association, supports the concept of the bill and applauds the efforts of the subcommittee to improve science, mathematical and technological education through the use of innovative technologies.

Our members have enormous expertise in the field of educational technology. We believe that this expertise should be harnessed and made available to our schools, colleges and universities.

We agree with the Office of Technology Assessment's recommendation that the Federal Government should help States or districts develop joint mechanisms for defining software needs, encouraging developers in acquiring software, and that these policies should be used to strengthen the commercial development of these products.

To promote these recommendations, we wish to work with the subcommittee to foster an increase in the use of technology in our schools and to assure a healthy private sector role in the process. We believe that the private sector involvement in the educational process can help to improve the real productivity in American schools.

To ensure maximum participation by the business community, we have the following recommendations to offer. Number one, in section 3 of the bill, we recommend that the language make it clear that businesses are eligible for the grants under (a)(1), which are the basic science and mathematic instructions in elementary and secondary schools. We recommend language here that would encourage partnerships between the educational institution or school district and the private sector.

While partnerships are already used in grant programs, it is the educational institution which is the grantee. We urge the subcommittee to encourage flexibility in awarding these grants to the recipients who, on a competitive basis, can best carry out the project, whether they are in the private, for-profit sector or the public sector.

Secondly, we recommend that NSF identify existing innovative programs and promote these programs. Number three, in giving the director the responsibility to disseminate innovative technologies, we recommend that the language of the bill make it clear that NSF does not duplicate existing distribution systems but utilize the distribution systems already in place in the private sector.

The problem is not distribution but availability of funds to buy programs and the ability of teachers to use the new technologies. We would also recommend that the National Science Foundation make an assessment of needs and award grants based on these needs.

The Office of Technology Assessment noted that the existence of numerous information channels makes it difficult for software producers to receive clear market signals and to adjust their designs accordingly. State and local initiatives to define curriculum needs and invite targeted software development have met with mixed results.

If the educational needs are more clearly defined at the national level, educational publishers who are anxious to produce what the education community wants will produce more products.

We would also like to recommend that a new program be added to section 3 which would specifically address the needs for continuing education and use innovative technologies to train people to do specific technical tasks. This Congress has just passed the Americans with Disabilities Act. Programs should be developed to help people with disabilities to adapt their skills to the workplace.

Last week, during the subcommittee's first day of hearings on this proposed draft, a number of witnesses commented on the need for increased emphasis on technological training for teachers. We support such an emphasis. Many of our members report that in selling new technologies to schools on a primary and secondary level, one of the biggest barriers encountered is a teacher's lack of experience with the new technologies.

We recommend that this bill provide for expansion of current Federal activities for teacher training and for in-service teacher training in the use of technology in the classroom.

We especially commend the committee for including section 3(d), Report on Learning Technology by the Office of Science and Technology Policy. We would recommend that OSTP also be required to recommend a lead agency for coordinating all programs among the Federal agencies and that OSTP include an inventory of innovative programs that are available.

Finally, we recommend that the funding for the programs in section 3 be increased to provide additional funds for development of new technologies and also funds for school districts to invest in technologies, both in programming and in equipment.

Our primary recommendations for improvement of the proposed draft are provisions which encourage maximum participation by the business community. Secondly, we see the need for better teacher education in the use of technology in the classroom and for coordination of programs.

Finally, in order to accomplish the goals of this legislation, we recommend that the funding level be increased and that the Federal Government provide funding for the school districts to take advantage of the development of innovative technologies.

If the United States is to be preeminent in the global marketplace, the Federal Government must take the lead to ensure the educational system can provide the basic technological skills needed to secure a position in the marketplace. Technology must be utilized to promote productivity in the schools and to produce a society that is scientifically and technologically literate.

Your proposal, along with our recommendations, can provide the vehicle to accomplish these goals. Thank you very much.

[The prepared statement plus letter of Ms. Stanion follows:]

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STATEMENT BY

THERESA STANION

DIRECTOR, GOVERNMENT RELATIONS
INTERNATIONAL COMMUNICATIONS INDUSTRIES ASSOCIATION

on the

DRAFT SUBCOMMITTEE BILL TO ESTABLISH PROGRAMS TO PROMOTE SCIENCE AND TECHNOLOGICAL LITERACY

before the

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

on

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Mr. Chairman and Members of the Subcommittee:

Thank you very much for inviting me here today to comment on the Subcommittee draft of the "Science and Technology Education Act of 1990."

INTRODUCTION

I am Theresa Stanion, Director of Government Relations for the International Communications Industries Association (ICIA). ICIA is a 50-year old organization formerly called the National Audio Visual Association. We represent audio, audio-visual, video and computer dealers, commissioned agents, manufacturers, software publishers and producers, independent media producers, film, video and software distributors, and education and trade publications. Our members include large corporations as well as small businesses that contribute substantially to local economies and play an important role in producing innovative technologies. Our members service and sell to virtually all areas of the economy, including corporate, industrial and government markets, as well as education. Some of our members specialize in the educational market, while others serve a broader clientele.

I would like to emphasize the following points:

(1) ICIA supports the concept of the bill and applauds the efforts of the subcommittee to improve science, mathematical and technological education through the use of innovative technologies. Like you, we believe that the use of technology -- computer, video, film -- is crucial to increasing the productivity of American schools.

(2) Our members have enormous expertise in the field of educational technology. We believe this expertise should be harnessed and made available to our schools, colleges and universities.

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(3) In "*Linking for Learning, A New Course for Education*" the Office of Technology Assessment (OTA) recommended that the Federal Government "*help states or districts develop joint mechanisms for defining software needs, encouraging developers, and acquiring software,*" and that these policies be "*used to strengthen commercial development of these products.*" The association agrees with this assessment and supports OTA's recommendations. To promote these recommendations, we wish to work with the subcommittee to foster and increase the use of technology in our schools, colleges and universities and to assure a healthy private sector role in the process. We believe that private sector involvement in the educational process can help to reverse the stagnating test scores and the decline in real productivity in American schools as found by the OTA in its study.

ICIA AND EDUCATION

Because of the expertise and interests of our membership, ICIA has long been active in private sector activities fostering the use of technology and media in education. We are a founding member of the Learning Through Media Coalition, which is composed of six national associations whose members are involved with the production, distribution, and the use of educational video and film. In addition to our association, ICIA, the other members of the coalition include the Association for Educational Communications and Technology (AECT), the American Film and Video Association (AFVA), the Association for Information Media and Equipment (AIME), the Consortium of College and University Media Centers (CCUMC) and the National Association of Regional Media Centers (NARMC). We are also members of the Committee for Education Funding.

The purpose of the Learning Through Media Coalition is to alert the public -- parents, educators, librarians, students and legislators -- to the power and potential of video and film as teaching tools for lifelong learning.

We cosponsor, with the Association for Educational Communications and Technology (AECT), INFOCOMM -- an exposition for communications equipment, software and accessories which features the latest developments in audio, audio-visual, video and computer products and technologies. Approximately 25 percent of the registrants attending the exposition are from the educational community.

ICIA'S POSITION ON TECHNOLOGY IN EDUCATION

It is the association's position that the implementation of technological programs will improve the productivity of the schools. It is also the association's firm belief that Congress must take the lead by providing the necessary authority and the necessary funding to help the nation's school systems fully utilize all available technologies. Without such Federal support, the development of new programs will be limited. School districts and states with enough monetary resources will be able to take advantage of the technologies that are available, and this will leave the poorer states and school districts behind.

At the annual meeting of the International Communications Industries Association in Anaheim, California on February 3, 1990, the association voted unanimously for the following resolution:

> *"Be it resolved that the International Communications Industries Association urge the U.S. Congress to designate the Department of Education as the lead agency for coordinating educational technology, that Congress underwrite software research and development by the private sector and that Congress appropriate the sum of $1 billion to help states implement the use of technology in the schools."*

With this in mind, we have the following eleven recommendations to offer.

ICIA RECOMMENDATIONS FOR CHANGES IN THE SUBCOMMITTEE DRAFT PROPOSAL

> RECOMMENDATION 1: ASSISTANCE FOR THE DEVELOPMENT OF INNOVATIVE TECHNOLOGIES IN BASIC SCIENCE AND MATHEMATICS INSTRUCTION SHOULD INCLUDE BUSINESS ENTERPRISES AND PROMOTE PARTNERSHIPS BETWEEN BUSINESS AND EDUCATION.

The subcommittee draft authorizes the Director of the National Science Foundation to:

> *"establish programs for promoting and supporting the development and dissemination of innovative technologies, including computer hardware and software for--*
>
> *(1) basic science and mathematics instruction in elementary and secondary schools; and*
>
> *(2) science and technological literary instruction and training of individual for technological careers."*

However, to carry out the program, under Section 3. (a)(1), the Director is to establish a merit review process awarding grants on the basis of:

> *"(A) the potential of the innovative technology to improve the productivity of basic science and mathematics education; and*
>
> *(B) the capability of the entity developing the innovative technology to provide broad and efficient dissemination of the technology to schools."*

We are concerned that the language in (A) and (B) will be interpreted to limit the grants to educational institutions and to exclude private companies who also invest time and resources to produce innovative programs for the schools, especially on the elementary and secondary levels. The draft language for carrying out Section 3, subsection (a)(2) specifically mentions *"business enterprises"* and also *"other relevant entities."* The expertise of businesses ought to be utilized and companies encouraged to participate in the program described in subsection (a)(1). We urge the subcommittee to use language here which specifically provides that *"business enterprises"* are eligible for these grants. We also recommend language that would encourage partnerships between the educational institution and the private sector in carrying out this program.

While partnerships are already used in grant programs, it is the educational institution which is the grantee. We see no reason why the educational institution must be the grantee. Grants should also be given to the private sector to either fulfill the task by itself or in partnership with an educational institution, school district or other for-profit company. We urge the subcommittee to encourage flexibility in awarding these grants to the recipients who, on a competitive basis, can best carry out the project.

RECOMMENDATION 2: NSF SHOULD BE DIRECTED TO IDENTIFY EXISTING INNOVATIVE PROGRAMS AND TO PROMOTE THESE INNOVATIVE PROGRAMS.

Section 3. (a) (3) states that the Director *"shall where feasible, consult, cooperate, and coordinate with analogous programs and policies of other relevant Federal agencies."* We recommend that NSF be directed to identify innovative programs that have already been developed, either by the public or private sector, and to promote these programs.

RECOMMENDATION 3: CLARIFY LANGUAGE SO THAT NSF CANNOT DUPLICATE PRIVATE SECTOR DISTRIBUTION SYSTEMS.

Section 3 also gives the Director the responsibility for the *"dissemination of innovative technologies"*. We are concerned by the ambiguity of this language. If by "dissemination" the subcommittee means "distribution," then this would require the NSF to duplicate distribution systems which are already in place by private companies who can do the job and have been doing it for years. NSF, to our understanding, is already using these companies for the distribution of programs. The problem here is not distribution, but the availability of funds for schools to buy the programs. If adequate funding is available and NSF has made known the availability of such programs, distribution channels are already in place.

RECOMMENDATION 4: REQUIRE NSF TO ASSESS THE TECHNOLOGICAL NEEDS OF THE ELEMENTARY AND SECONDARY SCHOOLS AND AWARD GRANTS BASED ON THIS ASSESSMENT.

Educational publishers are anxious to produce what the education community wants, needs and will ultimately buy. OTA accurately notes that:

> *"The existence of numerous information channels makes it difficult for software producers to receive clear market signals and to adjust their designs accordingly. State and local initiatives to define curriculum needs and invite targeted software development have met with mixed results."*

Many publishers are reluctant to make the investment necessary for producing innovative technologies unless they have some assurance that there will be a market for such technologies.

We see this as a role that the NSF should be engaged in -- researching and identifying the technological requirements of American school systems. This responsibility needs to be more clearly spelled out in the legislation. Before giving out grants, there needs to be a critical assessment of the needs of our elementary and secondary schools and awards granted on the basis of specific requirements. As noted, programs already developed, which address these needs, should be promoted by NSF.

At the same time the Director should be given the flexibility to grant awards to entities whose proposals are not part of this assessment, but which are so creative and unique that they are found by the Director to have the capability of advancing science and mathematics in new and innovative ways.

> RECOMMENDATION 5: ESTABLISH A NEW PROGRAM IN SECTION 3 TO PROVIDE FOR CONTINUING EDUCATION AND PROGRAMS FOR AMERICANS WITH DISABILITIES AND ADD A NEW FINDING IN SECTION 2 ON THE NEED FOR THESE PROGRAMS.

We recommend that the subcommittee add in Section 3 (a) a new program to provide for the development and use of technology in continuing education and retraining in technologically intensive areas. Although the draft addresses technical training, continuing education and retraining are important enough to the economy to warrant special targeting. There is a need for nondegree programs utilizing innovative technologies to train people to do specific technical tasks. Additionally, such programs could also be useful in providing special training to learners, be they in school or out, with special learning problems. This Congress has passed the Americans With Disabilities Act and such programs might be utilized to help businesses develop technologies that would enable businesses to employ the disabled.

In conjunction with expanding Section 3, we would also suggest in Section 2 another finding:

"Continued attention must be focused on the learner, both in and out of school, with special requirements and with reference to continuing education and retraining in non-degree programs."

RECOMMENDATION 6: BROADEN THE DEFINITION OF THE TERM "INNOVATIVE TECHNOLOGIES."

We are concerned that the definition of "innovative technologies" is too limiting. We recommend that this be broadened by integrating the definition utilized in H.R. 4331 introduced by Congressman Buechner. We recommend that Section 3, (4) read:

"(4) For purposes of this section the term 'innovative technologies' includes computer hardware and software, interactive video disks, CD ROM programs, information, audio, video, and communication technologies, and other similar items specified by the Director."

Defining the term as broadly as possible will give the Director the flexibility to utilize all types of communications technologies. Many school districts do not yet have the capability for using the more sophisticated technologies and this would prevent these school districts from full participation in this program. This would also allow the Director to utilize new technologies that may be developed after this bill becomes law.

RECOMMENDATION 7: PROVIDE GREATER EMPHASIS AND ADDITIONAL FUNDING FOR TECHNOLOGICAL TRAINING FOR TEACHERS.

Last week, during this subcommittee's first day of hearings on this proposed draft, a number of witnesses commented on the need for increased emphasis on technological training for teachers. In her testimony before this subcommittee on October 31, 1990, Dr. Linda Roberts of OTA said:

". . . technology is only effective in the hands of well-trained, enthusiastic teachers. Teachers need training time, and support to learn and incorporate technology into their teaching."

We support such an emphasis. Many of our members report that in selling new technologies to schools on the primary and secondary levels, one of the biggest barriers encountered is teachers' lack of experience with the new technologies. We recommend that this bill provide for expansion of current Federal activities for teacher training and for in-service teacher training in the use of technology in the classroom.

RECOMMENDATION 8: INCLUDE BASIC READING AND COMPREHENSION SKILLS.

While this draft addresses the question of basic mathematics and science on the elementary and secondary, levels, it does not, as H.R. 4331 did, address the problem of basic education. Before one can become proficient in math and science, one must have basic reading and comprehension skills. We recommend that the subcommittee include these basic skills in the legislation and promote development of such skills through innovative technologies.

RECOMMENDATION 9: REQUIRE OSTP TO RECOMMEND A LEAD AGENCY TO COORDINATE ALL TECHNOLOGICAL PROGRAMS AND TO DEVELOP AN INVENTORY OF INNOVATIVE PROGRAMS.

Section 3 (d) of the proposed draft addresses the crucial problem of listing all the Federal programs for technological innovation and making recommendations for improving coordination among the Federal agencies. We especially commend the subcommittee for including Section 3 (d) in the draft proposal. We recommend that the Office of Science and Technology (OSTP) be required to recommend a lead agency for coordinating all programs and products of such programs among the agencies. This is in keeping with OTA's finding that "there is no lead agency for educational technology and no coordinating structure across agencies." Such a requirement would address this problem.

We would also recommend that OSTP be required to include an inventory of innovative programs that are available. This should include programs that have been produced as a result of this legislation and other legislative initiatives, programs that NSF has identified, and, as recommended earlier, those innovative programs which have already been developed by the private sector.

Such an inventory would not only be useful to the education community, but would also serve as a guide for the private sector in deciding where new programs should be developed.

RECOMMENDATION 10: EXPAND SECTION 6 TO INCLUDE AN AWARD TO THE PRIVATE SECTOR FOR THE DEVELOPMENT OF INNOVATIVE TECHNOLOGICAL PROGRAMS.

We recommend that this section be expanded to include an award to a private sector company that has made a significant contribution toward innovative teaching technologies and programs. This award could be in conjunction with a university, school district or state program. Such an award would encourage private sector participation in advancing technological innovations.

RECOMMENDATION 11: INCREASE SECTION 8 AUTHORIZATION OF APPROPRIATIONS TO $ 500.000,000 TO PROVIDE ADDITIONAL FUNDS FOR DEVELOPMENT OF NEW TECHNOLOGIES AND FOR SCHOOL DISTRICTS TO IMPLEMENT THE TECHNOLOGIES.

We recommend that the funding for the programs in Section 3 be increased to a level of $500,000,000 for FY 1991.

This increase is to be used to:

(1) Increase the funding level for development of innovative technologies; and
(2) Provide funds for school districts to invest in new technologies -- both in programming and in equipment.

CONCLUSION

Our primary recommendations for improvement of the proposed draft are provisions which include maximum participation by the business community which already provides research, development and new technologies for use by the educational community.

Secondly, we see the need for better teacher education in the use of technology in the classroom and for coordination of programs.

Finally, in order to accomplish the goals of this legislation, we recommend that the funding levels be increased and the Federal government provide funding for the schools districts to take advantage of the development of innovative technologies.

If the United States is to be preeminent in the global marketplace, the Federal government must take the lead to ensure the educational system can provide the basic technological skills needed to secure our position in the marketplace. Technology must be utilized to promote productivity in the schools and to produce a society that is scientifically and technologically literate. This proposal, along with our recommendations, can provide the vehicle to accomplish these goals.

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July 10, 1990

Honorable Tim Valentine
Chairman
Subcommittee on Science, Research and Technology
Committee on Science, Space and Technology
Suite 2321 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Valentine:

Thank you very much for inviting me to appear as a witness on June 14, 1990 on the subcommittee draft science education bill, the "Science and Technology Education Act of 1990."

Following your hearing, I attended and spoke at "Power On!™ Technology & Learning Symposium" at the University of Idaho on June 25-28, where I encountered great interest in using technology in teaching and enthusiasm for your proposed legislation promoting the use of innovative technologies in education. The following are some observations from the symposium that I thought you and members of your Subcommittee would find valuable.

Many of the attendees who were classroom teachers identified two problems: the need for a central resource place for information, including results and comparative evaluations, on projects that are available, and the scarcity of funding for technology based projects. They made the point that classroom teachers do not have the time to search out and evaluate all the existing projects. They asserted that they had difficulty in finding funds to initiate and run technology based projects and in convincing their superiors of the need and the efficacy of such technologies.

The staff of the University of Idaho and of the Symposium, with whom I spoke, were familiar with the work of the National Science Foundation. They were concerned primarily with the validation of projects resulting from NSF grants, the dissemination of information about projects to school districts, and the availability of the projects to the schools through regular channels. They suggested that NSF validate the results of projects and that the results be readily available to schools throughout the United States. They pointed out that at the present time, NSF does not provide the collective results of projects having the same or a similar focus on a given subject. An individual in need of collective results to evaluate which project would be most suitable must go through all these projects and collect the results. Similarly, they agreed there is a need for a lead agency to coordinate and collect results of projects funded by Federal agencies since no mechanism to consolidate the results of similar projects sponsored by various Federal agencies presently exists.

Once innovative technology projects for educational purposes have been validated, positive steps are needed to disseminate information about them to school districts, according to university and symposium staff. They indicated his could be done through

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consulting teams and in-service education, or through regional laboratories. However, for efficient distribution and implementation to take place, it was suggested that once a project has been validated, and where feasible, the copyright for the program should either be sold or licensed for commercial distribution. Where commercial distribution is not feasible, the distribution could be subsidized.

Finally, university and symposium staff and participants alike identified teacher training as critical to the implementation of technology based projects. They saw a need not only for in-service training, but especially for pre-service training, i.e. training student teachers in the use of innovative technologies while they are still in college. Due to funding problems -- most universities accord a low funding priority to the technology requests of schools of education relative to the technology requests of their other schools -- it is difficult to get the required equipment and tools for university professors themselves at schools of education, much less for pre-service training in the use of technology. Many schools of education do not have technology laboratories.

Finally, it was suggested that NSF target monies for specific types of proposals and that there be more restrictions on the range of proposals. The NSF, in other words, should award grants to projects that will have the greatest benefit or where there is a specific need. In awarding grants, NSF should try to award grants on projects that would complement each other and provide a continuity of projects that would be available to the schools. In this process, NSF should look at models which have worked and promote these models.

In summary, I came away from the meeting with the general feeling is that there is a great need for what the committee is doing and a "hunger" for the kinds of innovative programs that the Subcommittee is targeting for development through the incentives in the proposed science education bill. I hope the views I have relayed in this letter are of help to the Subcommittee in its deliberations on the draft proposal.

Sincerely,

Theresa

Theresa Stanion
Director, Government Relations

[redacted] Honorable Jack Buechner, 502 Cannon House Office Building, Washington, DC 20515-2502
Dale Gentry, Dean, College of Education, University of Idaho, Moscow, ID 83843
Jack Davis, Faculty Development Coordinator, Washington State University, Pullman, WA 99164-5602
Don Holznagel, NW Regional Education Lab, 101 S.W. Main St., Suite 500, Portland, OR 997204
Dan Leonard, Idaho Education Association, Route 1, Box 148, Colton, WA 99113
Jerry Brong, Business Information inc., Manastash Road - Route 1, Box 1130, P.O. Box #9, Ellensburg, WA 98926-0009
James Wilson, Science Consultant, Subcommittee on Science, Research and Technology, 2319 Rayburn House Office Building, Washington, DC 20515
David J. Goldston, Special Assistant, Subcommittee on Science, Research and Technology, 2319 Rayburn House Office Building, Washington, DC 20515

Mr. **Valentine**. Thank you, ma'am.

Thank both of you.

Ms. Stanion, the resolution which was passed by your organization urged the Congress to designate the Department of Education as the lead agency for the coordination of educational technology; yet you recommend that NSF be authorized to spend half a billion dollars for expanding these technologies. Why didn't you recommend the Department of Education?

Ms. **Stanion**. Well, we thought it was the logical choice for coordinating all activities. We think NSF is the logical choice for dispensing of these science and technology grants, but we feel that there are a number of programs across the agencies, the Commerce Department, the Energy Department and that someone has got to coordinate all of these agencies. And we're not tied to the fact that it has to be the Department of Education.

We think there has got to be one agency that looks at what's going on in the Federal Government and coordinates all of it. This was our suggestion, but don't hold us to it completely. The important point here is that one agency take the lead and one agency coordinate all of the programs that the Federal Government is proposing and administering.

Mr. **Valentine**. Are you able to tell the subcommittee whether or not the Department of Education maintains an inventory of innovative programs, whether they are in this area, and to what extent?

M **Stanion**. I understand that in the 1987 Trade Reform Act that there was a provision that would establish an Office of Technology in the Department of Education, but to my understanding it has never been funded.

Mr. **Valentine**. Mr. Allison, I guess you'd be the proper person to answer this question. The bill requires a developer of an innovative educational technology to "provide broad and efficient dissemination of the technology to schools." Is this requirement realistic?

Mr. **Allison**. Pardon? Is it what?

Mr. **Valentine**. Is it realistic?

Mr. **Allison**. Yes, I think it is realistic; however, I think that some organization needs to have that responsibility and take it seriously. There is a bill right now, as was just mentioned. The Trade Act of 1987 required that all the technology presently developed by the Federal Government—and the Federal Government does develop a lot of learning technology—that that be made available to the general public.

Well, two years has gone by since the passage of that act, and today you cannot get a list of any technology developed by the Federal Government. You cannot get your hands on any of it because nobody has taken a serious interest in making all that information available to the general public, particularly the school systems. They could use a great deal of the information that has been developed by the Federal Government.

Mr. **Valentine**. Mr. Buechner?

Mr. **Buechner**. Mr. Chairman, I want to thank our two witnesses here. I have another item that Mr. Allison gave me from the Center for Business Industry and Labor that also has some comments that regard section 3 and section 5, and I'd like to have those entered into the record.

Is that all right, Mr. Allison?

Mr. **Allison**. That is correct, sir.

Mr. **Buechner**. Have these entered into the record also, Mr. Chairman.

[The information follows:]

Center for Business, Industry, & Labor

St. Louis Community College
300 South Broadway - Sixth Floor
St. Louis, Missouri 63102
Telephone (314) 539-5310

To: Ted Allison
From: Steve Long
Date: June 8, 1990
Subject: SRT Draft Education Bill

The following are some brief comments on the Draft Subcommittee Bill for the Science and Technology Education Act of 1990.

It is hard to argue with the findings of the subcommittee regarding the preparation of individuals to compete in a technological world or the adequacy of our formal and informal education infrastructure to prepare these individuals. Community Colleges have a dual role in that they are preparing individuals who will continue their education at the University level as scientists and engineers as well as preparing "those who chose not to become scientific or engineering professionals." It is highly commendable that the committee chose to include this latter group in their analysis of the problem. Community Colleges have been in the forefront of forming partnerships with the private sector to train the "non-professional" technicians.

Section 3 - Instructional Technologies - authorizes the solicitation of proposals for the dissemination of innovative technologies designed to aid the instruction of adults in literacy and technical skills relevant to the workplace. The committee is to be commended for its foresight in targeting adults already in the workplace. As we all know, the vast majority of the workforce which will take us into the next century is already working today. Community Colleges are again in a leadership position, with the private sector, in providing skills to adult workers.

Section 5 - Technician Training - is the most critical to the Community College. The National Advanced Technician Training Program is a giant leap forward in addressing the technical training needs of the nation. The Bill recognizes that the Associate Degree granting institutions are the most effective mechanism to achieve the goals outlined in the draft. It also recognizes that a key to success is collaboration with the private sector. Section 5(F) is extremely important to the success of this program. The sharing of program costs, equipment, facilities and the state of the art work experiences will greatly improve the delivery of technical training.

There are some areas of the Bill that could become problematic if not given careful consideration by the committee. First, there are numerous references to specific populations to be targeted in the Bill. For example, Section 5(a)(1) refers to "men and women...unemployed...dislocated by plant closings...left high school prior to graduating" etc. Section 5(a)(8)(B) refers to the adaptive and training needs of handicapped. This Bill should be focused on curriculum, technology and the delivery system of providing technology education. The objectives of the Bill will become more difficult to achieve if it becomes too focused on the eligibility of intended trainees rather than on improving the education infrastructure and disseminating the results. Second, the definition of advanced technology used in the Bill may not be broad enough to encompass all the possible applications of advanced technology. The Committee should take care not to limit or define too narrowly which technologies or which applications of technology should be considered under this Bill.

On the whole the Bill is well conceived and most likely will receive active support from Community Colleges.

Mr. **Buechner**. Ms. Stanion, in the statement to the subcommittee, you recommended that section 6 include an award to a private sector company for innovative teaching technologies and programs. Are you recommending a monetary award for the company, is that it? Or for the student?

Ms. **Stanion**. We're not recommending any monetary award. We would like to see private companies that produce innovative programs be recognized by NSF. Our association every year gives out a number of awards. We give no monetary compensation with these awards, yet people vie for these awards.

Mr. **Buechner**. So it's the prestige that's the important commodity there?

Ms. **Stanion**. The prestige of getting it from NSF, and I think it would stimulate other companies to try to get the award and to come out with more innovative technologies in the private sector.

Mr. **Buechner**. I think that's important, because, you know, some of our colleagues might think why should we be giving this money to companies, but you're just talking about the award, per se, and the prestige, and we should not preclude for-profit companies from receiving those.

Ms. **Stanion**. Right.

Mr. **Buechner**. I think it's a good idea. That's my personal opinion. Mr. Allison recommends the establishment of a national institute for learning technology. How do you feel about that recommendation?

Ms. **Stanion**. Well, from what I understand, I think it incorporates some of the ideas that I have asked be incorporated into the bill. I think we've got to use both the private and public sector in stimulating the use of technology in education, and that's what he is proposing. It also proposes to utilize a clearinghouse, from what I understand, and it also proposes the coordinating of activities across all the agencies and across the private sector and the public sector. From my advantage, I mean, from what I've said, we would support that concept.

Mr. **Buechner**. Now, you're recommending that private sector companies be eligible for the grants that section 3(a)(1) provided for. Normally, as kind of the same tact, I said Congress would be reluctant to do this. Can you suggest some compensating factors or requirements we might write in for for-profit companies if they're awarded these grants?

Ms. **Stanion**. Well, I think there are probably a number of things you can do. You can require in-kind contribution from the companies, or you could also write a statute that might require them to pay royalties to a special fund. And this fund could be used to further generate more monies for more grants in technology. I think you would get more for your money that way.

Mr. **Buechner**. Our learned counsel here just said that right now NSF does make grants directly to textbook publishers. Are you aware of that?

Ms. **Stanion**. No, because I talked to some of my members who are not textbook publishers, and they said that they had thought that pretty much these grants were given to non-profits.

Mr. **Buechner**. So I think we've got the camel's nose under the tent already.

Ms. STANION. But what I'm saying also is the way I read the legislation. It doesn't make it clear. I would like it to make it clear that they can give it to the one who can do the job, whether they're a for-profit or a non-profit. But the language of the bill does not clarify it, and I'm glad to hear that NSF is already doing it with book publishers. Then you have a precedent for putting it into the bill.

Mr. BUECHNER. We'll get some more information on that back to you so you can talk to some of your clientele on that.

Mr. Allison, thank you again, especially for some of the what I would call very far thinking type of proposals. You know, sometimes we have people come in and say they think it's a good bill or a bad bill, but they very rarely offer ways to expand it. We have people always asking for more money, but I think your recommendations are very laudable.

I'd like to ask you, how do you do a clearinghouse for dissemination of technologies? We talked about this in my office. You know, computers, software, and video disks, et cetera. How do we do that?

Mr. ALLISON. I think there are probably a number of things that can be done. The Department of Labor has an Advanced Learning Technologies Center, and I've been working with the Department of Labor, and we've been looking at that—how do we get out information on technology-based learning?

One of the things that we were looking at is to produce some form of a disk—disks are fairly cheap today, computer disks—list the technology that's available, and just send it out to the school districts. You know, a disk costs a few cents once you produce it to send out. One of the problems is collecting the data, to just get the people that have developed the technology to submit the information that they've developed.

I'll give you a classic example. The U.S. Department of Energy has developed over 3,000 training programs. The 3,000 training programs are all catalogued. They're both in hard form and magnetic form, but I defy anybody outside of the Department of Education [1] to get hold of a copy of that. Yet these are courses that were developed using Government money. Most of the courses are non-proprietary data; there's nothing secret in them. Why can't that data be made available to the school systems, to the public, whoever needs that data?

I think that Congress has to take a lead to the various agencies within the Government that they must make this data available to some central source, and I'm suggesting here that it be the institute. There may be a better mechanism than the institute, but at least something where the data and all the money that's being spent to develop this technology today—that we gather that data and make it readily available to the school systems or to the general public, in fact.

Mr. BUECHNER. I'm having our staff take notes here, and I think that's something we need to find out. That's a very good probe to put to us. How do we develop a program that trains and retrains teachers on this new based technology?

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[1] Witness intended to say "Department of Energy."

Mr. Allison. I think that's a fairly simple thing to do. If you look at what a lot of companies have done in training their sales people or in training the people that they sell their products to, there is absolutely no reason why mobile training classrooms couldn't be put together, fully equipped with technology-based learning systems. And these mobile training classrooms drive up to a school district, and the teachers there then would be trained on how do you use these systems. What is a technology-based system? How do you use it? How do you integrate it into your classroom?

I think if you develop teacher training in a central location, it's going to be very difficult for teachers to get there. I don't see it happening in the 4-year colleges today. In fact, I've called most of my contacts recently for another reason, all over the country, trying to find 4-year colleges that offer a curriculum involving instructional design using the latest technologies. I could find one college in the United States, one 4-year college, that offered an instructional design program that involved the use of learning technology.

Mr. Buechner. You mentioned to me in our meeting the other day that what computers are used for in most schools today is word processing and spreadsheets.

Mr. Allison. Yes, schools will get a computer in, and they'll tell you, oh, we're using computers in our school. But when you really get into the school and you start talking with the teachers, they're using that computer as a typewriter, a fancy typewriter, or they're using it to develop a spreadsheet. They are not using it teach their students, other than an application on a computer, but they're not really using it as a teaching device.

There are a lot of great programs today that have been developed. The University of Delaware has developed an outstanding music program. Florida State University has developed an outstanding science program for sixth through ninth graders. There are a number of math programs available. But almost no schools—there are a few schools that use that technology, but very few, and very few teachers in the United States would know how to use it if you gave it to them.

Mr. Buechner. I will say that in one of my school districts the art department has learned to use the graphics portion of the computer. And in my art contest for the district, I had three phenomenal—I don't know what you call the work, I guess it's art—that were graphic-generated by the computers, and at least somebody in that school district has found an extraordinary usage for it that maybe felt the same way. Give them a typewriter if they just want to do words, but this has got a function.

Have either of you studied the extent to which the existing NSF and Department of Education teacher training programs deal with the use of these technologies, and, if so, have you got any comments?

Mr. Allison. I have not studied it; so I couldn't comment.

Ms. Stanion. Me neither.

Mr. Buechner. All right.

Mr. Chairman, I thank our witnesses for spending the day here listening to us drone on, and hopefully everybody has learned something. I know I have.

Thank you, Mr. Allison and Ms. Stanion.

Mr. **Valentine**. Thank you, sir. When you come back, we'll put you first next time so you won't have to sweat all this out.

Ms. **Stanion**. Actually, I enjoyed listening to it.

Mr. **Valentine**. Before you leave here, Mr. Allison—I don't want to add to your burden—but could you give me a letter giving me more detailed information on the matters which you have described: your contact with the Federal Government and your effort to get to this material, this data, from them?

We promise you we won't use your name, if you would prefer just that we have a private conversation. We want to pursue that, and I would like to get as much detailed information as we can. That is, when the request was made, what was requested?

Mr. **Allison**. I'd be more than happy to do that.

Mr. **Valentine**. Thank you, sir.

[The information follows:]

Human Resource Consulting Services

June 21, 1990

Mr. James Wilson
U.S. House of Representatives
Committee on Science, Space, and Technology
Suite 2321 Rayburn House Office Building
Washington, DC 20515

Dear Mr. Wilson:

During the Science, Research and Technology Subcommittee hearing on the Subcommittee draft science education bill, I was asked by Representative Valentine to put my concerns on the transfer of educational technology in writing.

In August of 1988, congress passed the Omnibus Trade and Competitiveness Act of 1988. Title VI - Education and Training for American Competitiveness Subtitle B - Technology and Training of this act required the Department of Education, among other things, to:

- establish a comprehensive clearing house of all knowledge and education and training software developed or scheduled for development by or under the supervision of Federal Agencies
- develop and distribute detailed instructions and procedures for securing copies
- advise, consult with, and may provide grants to any prospective public interest user

Over the period of the last several months, I have been trying to obtain a listing of such material and instructions on how to obtain copies.

When making such requests I have been informed on several occasions that congress did not appropriate any money to implement this part of the Trade bill. From the research I have done I believe this is correct.

However, as important as education is to the United States and the well documented evidence on the need to improve our educational system, it is difficult for me to understand how federal agencies and the Department of Education with their staffs of thousands of people have not used two or three of their people to develop the required clearing house of information and procedures to make copies available to interested individuals and organizations.

#5 Briarwood, Ferguson, Missouri 63135 (314) 524-7305

Specifically, I have attempted to obtain training courses prepared by the U. S. Office of Personnel Management (OPM) at their National Independent Study Center. A written request was submitted on 13 February 1990, but so far the National Technical Information Services (NTIS) has not been able to secure the release of these programs from OPM.

In early May at a meeting in Washington, I was informed by an employee of the Department of Energy that they had prepared a listing of over 3000 training programs developed by or for the Department. I asked if I could see or get a copy of this list, and how I would go about obtaining a copy of selected programs. I was told that Management within the Department of Energy had not made a decision to release the program listing and/or training material.

The only true effort to share information about new technologies and packaged training programs was initiated by the Department of Commerce's, National Technical Information Service and the U. S. Department of Labor Employment and Training Administration's, Center for Advanced Learning Systems. The Roundtable, as it is called, over the past five years has invited individuals representing both federal agencies and the private sector to meet informally and discuss how federal agencies could better share information about the potentially shareable training programs that they develop. At the last Roundtable in September, 1989, these 30-40 people volunteered to take on some 19 tasks such as: how to get information on the best and most shareable programs and databasing them, developing guidelines for successful transfer of packaged training programs, seeking statutory authority for the Roundtable, copywrite, pilot a small number of training package transfers, establish communications, et. al. The Center for Advanced Learning Systems (CALS) is developing a database of information on these programs and the National Technical Information Service (NTIS) is offering to add agency products to their collection for distribution. This effort has essentially been a grassroots voluntary effort and has not yielded the results that could be achieved with the full backing of all federal agencies, including the Department of Education.

I hope the above information is useful to you.

If you have any questions you may contact me at (314) 524-7305.

Sincerely,

Theodore H. Allison

Theodore H. Allison

Mr. **Valentine**. Anything else?

[No response.]

Mr. **Valentine**. Well, thank you all very much for this appearance, and the subcommittee will stand adjourned.

[Whereupon, at 5:03 p.m., the subcommittee was adjourned, to reconvene at the call of the Chair.]

APPENDIX

JUN 26 1990

American Chemical Society

OFFICE OF THE PRESIDENT
Paul G. Gassman
President-Elect, 1989
President, 1990
Immediate Past President, 1991

1155 SIXTEENTH STREET, N.W.
WASHINGTON, D.C. 20036
Phone (202) 872-4600

June 25, 1990

The Honorable Tim Valentine
Chairman
Subcommittee on Science, Research and Technology
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, D.C. 20515-6301

Dear Mr. Chairman:

In November 1989, the American Chemical Society released ***Education Policies for National Survival***, a report that sets forth specific policy recommendations to help alleviate the current crisis in science education facing the U.S. Several areas addressed in the report are of particular relevance as your Subcommittee deliberates the draft bill, the "Science and Technology Education Act of 1990." The ACS is concerned that the on-going and long-standing crisis in mathematics and science education threatens the future capability of the U.S. to compete in today's technology driven global marketplace. However, the Society also believes that there are effective means that can be employed to address this crisis. The following comments are based upon the recommendations contained in our November 1989 "Report" and pertain to specific sections of your draft bill.

Instruction Technologies

The bill calls for NSF to promote and support the development of innovative technologies for science and mathematics teaching. Science is all too often taught in elementary and middle schools as a book activity rather than as a hands-on exploration of the natural world. The ACS strongly supports using the computer for simulations and drills and to enhance data collection, but not as a substitute for laboratory experiences. Hands-on science must be supported by adequate budgets for supplies, equipment, and maintenance.

Informal Science Education

Research confirms that many decisions regarding future course work and career options are made by students during their prehigh school years. Thus, the curiosity and wonder shown by the youngest of learners about the natural world must be carefully nurtured. Out-of-school science experiences for young people reinforce their interest in science and mathematics and encourage them to consider careers in these areas. The ACS endorses the provisions in the draft bill which provide for increased efforts to develop a scientifically literate citizenry through informal education and is especially supportive of programs to attract young women and minorities into the quantitative disciplines.

Technician Training

The Nation's two-year colleges have a potential to meet immediate pipeline needs in science and engineering because they provide an entry route into the science and engineering pipeline, especially for women and minorities. They also prepare technicians and technologists who play a vital role in the Nation's research and development effort, and they often develop programs customized to the needs of specific local industries. The Society is pleased that the bill closely links the technician training provisions to two-year colleges.

The American Chemical Society supports the expansion of mechanisms and funding opportunities to provide instructional laboratory equipment and resources for acquiring and adapting educational technologies to classroom use. As noted in Section 5(a)(E) of the draft bill, state-of-the-art instrumentation is essential to educational and training programs designed to prepare and upgrade technicians in advanced-technology fields.

In ***Education Policies for National Survival***, ACS gave particular attention to the role of two-year colleges as vehicles which have the potential to meet immediate science and engineering pipeline needs. The Society is gratified to see strong support in the bill for partnerships between two- and four-year colleges. In addition, the ACS supports the provisions under Section 5(b)(2) for grants for partnerships with secondary schools in the community served by the college. Such associations serve to identify talented youth and to provide enrichment programs that would make it possible for such students to complete high school and to move on to higher education.

While the Society is supportive of these programs, we are concerned about the duplicative effort of this bill in light of the Vocational Education reauthorization bill currently in conference committee.

Undergraduate Scientific Education

The Science, Engineering, and Mathematics Educator Award program within the draft bill will recognize undergraduate college or university teachers who have demonstrated outstanding ability and dedication to teaching undergraduate students. The ACS believes that the low status of teaching as a profession is one of the faults that permeate the entire science education system and, therefore, mechanisms that will improve the status of teachers are welcome and needed. Teaching and research must be considered to be of equal importance. Although it is not a complete solution, the Award program can begin to increase the prestige of the teaching profession and the image of teachers.

The Society also is supportive of the provisions in the bill that provide awards for curriculum enhancement. The quality of undergraduate science education must be preserved to create both a workforce of professional scientists and a scientifically literate citizenry. Colleges and universities must be encouraged to design introductory courses that effectively convey to nonscientists the nature and impact and excitement of the chemical sciences and technology. In addition, the ACS hopes that awards also will be given to faculty who wish to develop alternative approaches to the teaching of pre-college chemistry.

Graduate Fellowships

Finally, the ACS supports the proposed increase in the number of new graduate fellowships awarded by NSF and advocates an increase in the number of fellowships awarded to women and minority students. The underrepresentation of women and minorities in any of the quantitative disciplines has implications for science education policy formulation at all levels. Unless programs are developed to attract and retain more women and underrepresented minorities into science, the Nation will not be able to meet its technical personnel needs in the next century.

The American Chemical Society is the world's largest scientific organization representing over 140,000 chemical scientists. The Society's commitment to improvements in science education is well documented: ACS has developed over 100 programs in support of science instruction in the preschool, elementary and middle school years and chemical education in high schools, colleges, and beyond. As Congress debates the merits of the "Science and Technology Education Act of 1990," the Society would be pleased to provide any input or assistance you may need.

Sincerely yours,

Paul G. Gassman

Paul G. Gassman

cc: Members, House Subcommittee
on Science, Research and Technology

AMERICAN COUNCIL ON EDUCATION
Division of Governmental Relations

June 25, 1990

The Honorable Tim Valentine, Chairman
Subcommittee on Science, Research
and Technology
Committee on Science, Space and Technology
2319 Rayburn House Office Building
Washington, DC 20515

Dear Mr. Chairman:

The undersigned higher education associations wish to express our support for the Science and Technology Education Act of 1990 scheduled for markup by the Subcommittee shortly. The bill would strengthen the role of the National Science Foundation in improving science education and teaching at the elementary, secondary, and collegiate levels.

In particular we support the provisions of Section 5, which would encourage the development of training programs for advanced-technology occupations at associate-degree-granting colleges, establish centers of excellence in advanced technician training and undergraduate education in math and science, and encourage partnerships between two-year colleges and secondary schools in math science education, as well as partnerships with four-year institutions to improve articulation in scientific programs.

We also support Section 6, which would establish awards to recognize teachers making outstanding contributions to undergraduate science instruction, and Section 7, which would expand the number of NSF Graduate Fellowships, particularly for women and minorities.

Sincerely,

Charles B Saunders Jr
Charles B. Saunders, Jr.
Senior Vice President

This letter is written on behalf of:
American Association of Community and Junior Colleges
American Association of State Colleges and Universities
American Council on Education
Association of American Universities
Association of Catholic Colleges and Universities
Association of Jesuit Colleges and Universities
Association of Urban Universities
Council of Independent Colleges
National Association for Equal Opportunity in Higher Education
National Association of College and University Business Officers
National Association of Independent Colleges and Universities
National Association of State Universities and Land-Grant Colleges

cc: Members of the Subcommittee

One Dupont Circle, Washington, D.C. 20036-1193 (202) 939-9355
FAX (202) 833-4760

JUN 25 1990

ACCT

Joint Commission
On Federal Relations

AACJC

June 22, 1990

The Honorable Tim Valentine, Chairman
Subcommittee on Science, Research and Technology
U.S. House of Representatives
2319 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Chairman:

Your new science bill, for which you have scheduled markup June 28, is a real winner -- surely so in the eyes of the AACJC, ACCT, and the nation's community, technical, and junior colleges.

Dallas Garrett of Central Piedmont Community College, Charlotte, was entirely correct in testifying to your Subcommittee last week that the articulation program is the gravest lapse in American higher education. President Bush's budget request for Science Education was an open invitation to Congress and the NSF to solve the problem.

Vast gains in national productivity are being sacrificed on the altar of academic egos, which raise inexcusable hurdles to students trying to transfer from two-year to four-year colleges. U.S. competitiveness can ill afford such ivory towered luxuries. Since more than half the students going to college now start in community colleges, it is imperative that NSF assert much greater leadership in improving undergraduate science, engineering and technical education and building the articulation bridges state by state. Your bill provides essential building blocks to this process.

Our warmest appreciation for your vision and leadership.

Respectfully,

Frank Mensel

Frank Mensel
Vice President for Federal Relations, AACJC
Director of Federal Relations, ACCT

FM:egd

cc: Joint Commission
Representative Roe
Representative Walgren
Representative Boehlert
Senator Kennedy
Senator Pell
Senator Mikulski
Senator Hatch
Senator Kassebaum

Association of Community College Trustees
1740 N Street, NW
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Auriel A. LaFond
President

JUL 25 1990

JW

July 16, 1990

Congressman Tim Valentine
Chairman, Subcommittee on Science, Research and Technology
Suite 2321 Rayburn House Office Building
Washington, DC 20515

Dear Honorable Valentine:

I have read the statement by Theresa Stanion, Director, Government Relations International Communications Industries Association on the Draft Subcommittee Bill to establish programs to promote Science and Technological literacy before the Subcommittee on Science, Research and Technology Committee on Science, Space and Technology U. S. House of Representatives on June 14, 1990, at the Rayburn House Office Building. I am writing to let you know that I support Ms. Stanion's position, and I'm requesting that you support the legislation, "The Science and Technology Education Act of 1990" and ICIA's position.

I will appreciate hearing of your support, which I feel will be in the best interest of the country and our educational process.

Sincerely yours,

Auriel A. LaFond

AAL:km

915-267-6327
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AIME

Association for Information Media and Equipment
P.O. Box 865, Elkader, Iowa 52043
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July 18, 1990

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Honorable Tim Valentine
Chairman
Subcommittee on Science, Research and Technology
Committee on Science, Space and Technology
Suite 22321 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Valentine:

On behalf of the Association for Information Media and Equipment (AIME), I would like to voice our support for the Subcommittee's draft science education bill, the "Science and Technology Education Act of 1990."

The Association for Information Media and Equipment (AIME) is the national trade association for commercial producers and distributors of information film and video and those companies and organizations manufacturing equipment or supplying professional services or laboratory services to the industry.

At the June 22, 1990 Board Meeting of the Association for Information Media and Equipment, Theresa Stanion of the International Communications Industries Association (ICIA) made a presentation of the Subcommittee's draft science education bill, the "Science and Technology Education Act of 1990."

Our association commends you and the Subcommittee for your work in this area. We would like to go on record supporting the testimony of Theresa Stanion.

Technology, as you are well aware, is a powerful learning tool. Our concern is that the definition of technology be broad enough to include not only computers and computer software, but also film and video.

Our eyes are our most powerful learning tools. By the time we are adults, 70 percent of all we know came to us through our eyes alone. And when we see and hear together, studies show we have 30 percent greater retention.

Educational films and video programs, by themselves or in combination with other technologies, give students an advantage in learning and absorbing subject matter quickly and promotes depth, understanding and retention of the subject matter. Film and video have proven they are efficient and effective tools for learning.

We ask that our letter be considered part of the Subcommittee's record on this legislation.

Thank you very much for your support of education and the use of technology to improve our education system.

Sincerely,

Ray L. Short Jr

Ray L. Short, Jr., President of RTI-Research Technology
International
Board of Director and President of AIME

cc: AIME Board of Directors
Ivan Bender, AIME General Counsel
Theresa Stanion, ICIA

AUG [illegible]

Northwest Tri-County Intermediate Unit
Pointing Toward Quality Education in Crawford, Erie and Warren Counties
252 Waterford Street
Edinboro, Pennsylvania 16412
814/734-5610

July 27, 1990

The Honorable Tim Valentine, Chairman
Committee on Science, Space and Technology
Subcommittee on Science, Research and Technology
2319 Rayburn House Office Building
Washington, DC 20515-6301

Dear Chairman Valentine:

I would like to encourage your continued support of your subcommittee's draft education bill, the "Science and Technology Education Act of 1990."

Our nonprofit regional media center provides technology services to 63,000 students and 5000 teachers in three counties of northwestern Pennsylvania. These services include: a circulating video library, video duplication, instructional television, satellite reception and redistribution, microcomputer software preview, training in all types of technology applications in the classroom, hardware repair, electronic mail networking, and consultation.

We know that technology has a vital role to play in the schools we serve -- as the demand for our services increases and as we examine the current educational research and practices. We see on a daily basis the excellent use of video programming in classrooms by our teachers. Instructional film and video programming bring the world into the classroom, provide students with experiences otherwise unavailable, provide extreme closeups, demonstrate skills as no other medium can, allow up-to-the-minute reporting, and motivate learning. Research has shown that by themselves, or in combination with other media, they give students an advantage in learning and absorbing curriculum quickly and promote depth, understanding and retention of the subject matter.

I thus urge you to **include film and video in the bill's definition of technology**, to give schools the flexibility of defining the needs and curriculum areas where these federal dollars can be of assistance, and to make regional educational service agencies such as ourselves eligible for funding.

Thank you very much for your support of education and the use of technology to improve our education system.

Sincerely,

Linda Cook

Mrs. Linda S. Cook, Director
Instructional Media Services

cc: The Honorable Thomas Ridge

AUG 01 1990

Burlington County
AVAC
The *Teaching* Resource

Burlington County Audio-Visual Aids Commission
122 High Street, Mt. Holly, New Jersey 08060
(609) 265-5053

Director, Mr. Mark L. Richie

Chairman, Dr. John M. Sherry
Secretary, Dr. W. George Batezel

Honorable Tim Valentine, Chairman
Subcommittee on Science, Research and Technology
Suite 22321 Rayburn House Office Building
Washington, DC 20515

July 27, 1990

Dear Chairman Valentine:

I am past president of both the American Film and Video Association and the National Association of Regional Media Centers. Both of these associations are interested in promoting the effective use of video and film, along with other technologies, in the educational process.

I would like to express my support for the Subcommittee's draft science education bill, the "Science and Technology Education Act of 1990" and cannot over emphasize the importance of including educational video and film in the definition of technology within the bill.

Educational video and film have long been recognized by educators as effective teaching tools and vital to the classroom communication process. Their effective use is even more important when used with students that have been raised on video to the extent that it has become their second language.

Over 300 regional media and technology centers across the country provide over 22 million students with access to thousands of educational video/film titles, computer programs and videodiscs. As technologies merge with the advent of videodisc driven by computer systems, the inclusion of video and film in the definition of "technology" becomes imperative. Educators need to excercise flexibility to choose the appropriate technology to fit the learning needs of their students.

Many of the regional media centers in the United States were built in part on funding through the now long gone Elementary and Secondary, and National Defence Education Acts. For the first time since those acts expired, if film and video are included in the "Science and Technology Education Act", education will have the opportunity to get much needed support to update and expand the video/film and videodisc resources needed to support science education into the next century.

I would ask that this letter be considered part of the Subcommittee's record on this legislation.

Thank you very much for your support of educational technology.

Sincerely,

Mark L. Richie

Mark L. Richie, Director